Pond Dynamics/Aquaculture Collaborative Research Support Program

Fifteenth Annual Administrative Report

1 August 1996 to 31 July 1997

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1. Introduction

The ability of the world fishery to meet the growing global demand for fish is seriously threatened. World fish production from all sources is nearly 100 million tons annually, a level that approximates—and for some fishery resources exceeds—maximum sustainable yield (Brown et al., 1994; The World Bank, 1992). Aquaculture is a primary means through which significant future increases in the world fish supply, an important protein source in many less developed countries, can be achieved.

The Pond Dynamics/Aquaculture Collaborative Research Support Program (PD/A CRSP) conducts research that contributes significantly to the removal of major constraints to aquacultural development, thereby promoting economic growth and increasing food security. This report describes the activities and accomplishments of the PD/A CRSP during the period 1 August 1996 to 31 July 1997.

The PD/A CRSP is funded by the United States Agency for International Development (USAID), under authority of the International Development and Food Assistance Act of 1975 (PL 94-161) and by the universities and institutions that participate in the CRSP. This cohesive program of research is carried out in selected developing countries and the United States by teams of US and host country scientists. Now operating under its fourth USAID grant since 1982, the CRSP is guided by the concepts and direction set down in the *Continuation Plan 1996-2001*, which was awarded funding under USAID Grant No. LAG-G-00-96-90015-00. This grant authorizes program activities from 1 August 1996 to 31 July 2001. An overview of CRSP history and how the program has evolved since its inception is provided in Appendix C.

The activities of this multi-national, multi institutional program are administered by Oregon State University (OSU), which functions as Management Entity (ME) and has technical, programmatic, and fiscal responsibility for the performance of grant provisions. ME activities at OSU are carried out through a Program Management Office, which is supported in the task of program administration by three advisory bodies: the Board of Directors, the Technical Committee, and the External Evaluation Panel. The relationships among these bodies and their respective roles are described in more detail in Chapter 5.

Research conducted by the PD/A CRSP since 1982 has helped to remove some of the constraints facing aquaculture development. Still, aquaculture continues to be hampered in several important areas. In developing the *Continuation Plan 1996-2001*, the CRSP undertook an in-depth constraints analysis. That analysis led to the identification of a number of major constraints that limit the development of extensive to semi-intensive sustainable aquaculture systems. Chief among these were:

- Inefficient and inconsistent aquacultural productivity.
- Negative environmental effects resulting from aquaculture operations.
- A poor understanding of social and economic factors.
- Insufficient human capacity development.
- Poor or outdated information management.
- Limited networking capacities.

The *Continuation Plan 1996-2001* responds to the first three of these factors by setting a **research agenda** that addresses constraints to aquacultural productivity, environmental effects, and social and economic aspects of aquaculture. Descriptions of the CRSP research program background and framework as well as a summary of the research carried out in the reporting period under the program's Eighth Work Plan can be found in Chapters 3 and 3.1, respectively. Chapter 3.2 contains the abstracts of technical reports completed by CRSP researchers during the reporting period.

The second three constraints are addressed by a **research support agenda** committed to improving human capacity development, information management, and networking. To carry out that agenda, the program now has a new Research Support component which is comprised of three projects:

- A new Education Development project dedicated to strengthening human capacity in participating countries and regions;
- A project that manages the CRSP Central Database, the largest repository of standardized data related to aquaculture; and
- An Information Management project for reporting and dissemination of project and program outputs via publications and a central website.

Chapters 4.1 through 4.3 describe the activities of these three research support projects during the reporting period.

The PD/A CRSPs multidisciplinary team of researchers represents a wide range of US and international aquacultural experience. During the reporting period, participating US institutions included:

- Auburn University;
- Oregon State University;
- Southern Illinois University at Carbondale;
- The University of Michigan;
- University of Arizona;
- University of Arkansas at Pine Bluff;
- University of California at Davis;
- University of Hawaii (through participation on the Technical Committee);
- University of Oklahoma;
- University of Texas.

Research activities were conducted at host country sites in Honduras, Peru, Kenya, Thailand, and the Philippines, and also at the participating US institutions. Memoranda of Understanding, representing a formal tie between a US and host country institution, which were in place during the reporting period include those between:

- International Center for Aquaculture and Aquatic Environments, Auburn University, and the Ministry of Natural Resources, Republic of Honduras;

- Southern Illinois University, Carbondale, and the Institute for the Investigation of the Peruvian Amazon and the National University of the Peruvian Amazon;
- Oregon State University Fisheries and Wildlife Department and the Department of Fisheries, Ministry of Wildlife and Tourism, Kenya; and
- The University of Michigan and the Asian Institute of Technology, Thailand.

Colossoma harvest at Iquitos, Peru.

Developing and maintaining links between the collaborating universities and government ministries, departments of agriculture, and the private sector around the world strengthens the PD/A CRSPs network of organizations and individuals engaged in sustainable aquaculture and development. The objective of networking efforts is to facilitate the development of linkages among CRSP researchers and among governmental and non-governmental organizations. Chapter 4.4 describes linkages and connections made not only by CRSP researchers in the field and reported to the Program Management Office during this reporting period, but also those maintained by the Program Management Office. CRSP participation in scientific meetings and contributions to scholarly publishing is also described. These are all significant indices of CRSP outputs.

Literature Cited

Brown, L.R., H. Kane, and D.M. Roodman, 1994. Vital Signs 1994: The Trends that are Shaping Our Future. W.W. Norton and Company, New York, 160 pp.

The World Bank, United Nations Development Programme, Commission of the European Communities, and Food and Agriculture Organization of the United Nations, 1992. A Study of International Fisheries Research, Policy and Research Series 19. The World Bank, Washington, D.C., 103 pp.

2. Highlights of Program Activities

Regional Plans

In order to broaden the CRSPs sphere of relevance, CRSP project researchers this year developed preliminary regional plans detailing activities for the next five years for each region in which the CRSP is active—Central America, South America, East Africa, and Southeast Asia. Regional plans are conceptualized as a means to establish a shared vision for all actors in the region and to ensure integration of CRSP research efforts and research support activities.

After discussions at the February 1997 Annual Meeting in Seattle, Washington, prime site Principal Investigators developed and submitted draft regional plans to the Program Management Office (PMO). The CRSP Board of Directors and the External Evaluation Panel reviewed the draft plans to ensure that they met a set of minimum requirements (these included items such as identification of region; regional objectives; cross-cutting research integration; regional research needs; institutional strengthening; implementation/plan of action; and impact indicators). After review by the Program Director, the draft plans were accepted with contingencies. The PMO collected these preliminary plans into a Working Paper on Regional Plans to provide a starting point for initiating regional activities. The draft Regional Plans will continue to evolve through an iterative process as more regional players and stakeholders are identified and included in CRSP planning activities. The next Annual Meeting in February 1998 will present an opportunity for Principal Investigators to further refine regionalization strategies.

Impact Indicators

The results framework of the PD/A CRSP *Continuation Plan 1996-2001* provided the basis for the design of impact indicators which were developed jointly by principal investigators and the PMO. These quantifiable characteristics or results of PD/A CRSP research activities are part of all project subcontracts. Principal investigators are required to collect the necessary information and report results to the PMO.

Starting in July of this year, a review of impact indicators was conducted to determine whether they adequately reflect and record project impact. An advisor to the program with expertise in project monitoring has been working with researchers directly to help them identify and formulate indicators for their project sub-contracts that measure impact (rather than output). Several researchers have already made changes to their indicators and are in the process of having these accepted through the PMO. This process is still on-going. The end result is that the program will have a much better framework for determining project impact.

Philippines Prime Site Request for Proposals

Under previous grants, the Philippines served as a companion site to the prime Southeast Asia site in Thailand. *The Continuation Plan 1996-2001* identified the Philippines as a potential prime site. On 1 April 1997, the Management Entity

released a restricted Request for Proposals (RFP) for the Lead Institution of the PD/A CRSP Philippines Project with a deadline for submissions of 5 May 1997. The RFP was developed with input from the CRSPs three advisory groups. The RFP elicited two proposals, which were sent out for review by the ME to three external and two internal reviewers. The reviewers' evaluations were then distributed to the Board of Directors and External Evaluation Panel for a recommendation. Finding the reviews to be inconclusive, the ME elected to reopen the RFP. On 30 June 1997, the RFP was reopened with a new deadline for submissions of 1 October 1997.

Ninth Work Plan Request for Proposals

On June 8, 1997, the ME issued a restricted RFP for the Ninth Work Plan for CRSP research to be carried out in the period 1 July 1998 to 30 June 2000. The RFP was developed with input from the CRSPs three advisory groups and invited proposals for regional work plans, cross-cutting research work plans, and work plans for specific research support activities. The deadline for submissions was 1 October 1997.

Publication of "Dynamics of Pond Aquaculture"

This reporting period saw the publication of the new multi-authored book entitled, "Dynamics of Pond Aquaculture," published by CRC Press/Lewis Publishers. This new collection, which approaches aquaculture production as part of the larger agroecosystem, was edited by CRSP Director Hillary Egna and CRSP Principal Investigator Claude Boyd. Director Egna also wrote two of the book's 16 chapters. A great number of CRSP researchers were contributors to this effort. A sampling of reviews received by the manuscript demonstrates the relevance and timeliness of this new text: "A state-of-the-art study of aquacultural research" and "Theory, practice, the latest techniques, and human factors—all covered in this complete reference."

InterCRSP Activity

InterCRSP activity during the reporting period involved progress toward implementing a West Africa Natural Resources Management InterCRSP project that brings together seven CRSPs, the PD/A CRSP among them, and nine African countries. Six proposals were received in response to a Request for Proposals, and four of these were reviewed favorably enough to receive funding. PD/A CRSP Director Hillary Egna served as one of the reviewers. A University of Arkansas at Pine Bluff researcher, Pierre-Justin Kouka, represents the PD/A CRSP in InterCRSP efforts in Cape Verde, The Gambia, Mali, and Senegal, which are presently focusing on reversing soil acidification, loss of organic matter, reducing the effect of runoff on food production systems, and economic analysis.

3. Research Program Framework

The *Continuation Plan 1996-2001* program framework, and the foundation for the current portfolio of PD/A CRSP research projects, consists of two building blocks: research in sustainable production systems and research support activities. This chapter and the next two address the former; research support activities are reported in Chapters 4 through 4.3.

The sustainable production systems research framework is organized into the areas of production optimization, environmental effects, and social and economic aspects. Each area is further subdivided into specific *research themes*, which are the thematic areas of research needed to remove constraints to the development of more sustainable aquaculture (see Chapter 1). The results framework for research areas as presented in the *Continuation Plan 1996-2001* is summarized in Table 1, and the results framework for research themes is provided in Tables 2 through 4. Research areas and their respective themes are listed here:

Research Area:	Production Optimization
Research Themes:	Pond Dynamics
	Feeds and Fertilizers
	Reproduction Control
	Aquaculture Systems Modeling
	New Aquaculture Systems/New Species
Research Area:	Environmental Effects
Research Themes:	Effluents and Pollution
	Appropriate Technology
	Responsible Science Policy
	Geographic Information Systems: Planning, Policy, and Global Data Analysis
Research Area:	Social and Economic Aspects
Research Themes:	Marketing and Economic Analysis
	Adoption/Diffusion
	Food Security
	Regional Analysis: Human-Environment Interactions
	Decision Support Systems
	Product Diversification

Eighth Work Plan

The CRSPs Eighth Work Plan, describing activities to be conducted by the CRSP during the period 1 August 1996 to 31 July 1998, was developed by the CRSP Technical Committee and is the first work plan designed within the framework of the *Continuation Plan 1996-2001*. Previous activities were described in the Interim Work Plan which covered the period from 1 September 1995 to 31 August 1996. The Interim Work Plan was necessitated by a cost-extension to the preceding grant which was scheduled to end with the Seventh Work Plan.

The first three CRSP work plans specified identical experiments (called Global Experiments) at all CRSP sites to provide a baseline for comparisons among sites. This approach was changed starting with the Fourth Work Plan when different, but related experiments were conducted at the various sites. The particular topics studied at each site were based on the research and information needs in each country, as identified by the Technical Committee.

In comparison with previous work plans, the investigations contained in the Eighth Work Plan reflect the broadening of research which was proposed in the *Continuation Plan 1996-2001* as well as increased integration among sites. In addition to specific research activities implemented at prime sites in Africa, Asia, and Latin America, the Eighth Work Plan includes, for the first time, work plans for cross-cutting research.

Cross-cutting research is research that may be conducted at one or more PD/A CRSP sites and whose results may have wider application than results from prime and companion site investigations. This research builds upon and expands results obtained through earlier PD/A CRSP efforts. In the chapters that follow, reports relating to cross-cutting research activities are grouped under the heading, "Global Research."

UAPB researcher Dr. Rebecca Lochmann demonstrates fish dissection and tissue sampling techniques to station technicians during a visit to the Sagana Fish Farmin Kenya in June 1997.

TABLE 1. RESULTS FRAMEWORK FOR RESEARCH AREAS WITHIN THE PRODUCTION SYSTEMS PD/A CRSP BUILDING BLOCK.

PRODUCTION SYSTEMS				
RESEARCH AREA	OBJECTIVE	CAUSAL ASSUMPTIONS	MEASURE	TARGET
Production Optimization	* To increase the overall sustainability of aquacultural production systems through production optimization.	* Productivity and sustainability can be increased with better management of pond inputs, waste reduction, use of underutilized resources, and the conservation of non-renewable resources.	* More sustainable, efficient production systems appropriate for the biophysical environment.	* Improved scientific understanding of pond processes. * Improved pond management strategies. * Significant advances in reproduction technology. * Development of alternative aquacultural systems.
Environmental Effects	* To minimize the detrimental environmental impacts of aquaculture operations through improved pond management.	* Sustainable aquaculture is possible only in a healthy environment. Detrimental effects of aquaculture operations can be reduced or eliminated through changed management development.	* Reduced detrimental environmental impact of aquaculture operations.	* Development of methodologies to assess and reduce negative environmental impacts of aquaculture operations.
Social and Economic Aspects	* To increase our understanding of the social and economic implications of aquaculture development.	* Successful aquaculture development is contingent upon the social and economic constraints of each location.	* Improved viability of subsistence and commercial aquaculture farms at various sites.	* Positive net returns to capital investment. * Positive financial and nutritional impact on participating household communities.

TABLE 2. RESULTS FRAMEWORK FOR RESEARCH THEMES WITHIN THE PRODUCTION OPTIMIZATION PD/A CRSP RESEARCH AREA.

PRODUCTION OPTIMIZATION				
RESEARCH THEME	OBJECTIVE	CAUSAL ASSUMPTIONS	MEASURE	TARGET
Pond Dynamics	* To further our understanding of the influence of pond processes on pond productivity.	* Knowledge of pond processes and organisms is necessary to improve productivity and fine-tune existing pond management guidelines as well as to reduce production losses and waste as aquaculture systems become more intensified.	* Improved predictability of pond processes and pond productivity.	* Illumination of the role of heterotrophy on pond production. * Development of pond bottom management techniques through a better understanding of pond soil-water interactions.
Feeds and Fertilizers	* To optimize use of pond inputs.	* Optimal fish growth can be achieved if the culture species' nutritional needs are addressed.	* Improved capabilities for prescribing optimal feed/fertilizer inputs to meet economic and environmental criteria.	* Reduce inputs of fertilizers and/or feeds to produce 1 unit of fish.
Reproduction Control	* To develop short- and long-term solutions to reproduction technology problems.	* Guaranteed seed supply and reliable broodstock is essential for the undertaking and maintenance of fish farming. Gender manipulations add management options which increase economic viability in intensified systems.	* Improved efficiency, efficacy, and safety of steroid use. * Successful production of sufficient amounts of YY-males. * Successful use of piscivorous fish to control excess tilapia offspring.	* Development of procedures that guarantee the safety of animals and farmers during steroid use. * Demonstration of the functional nature of YY-males for producing all male tilapia offspring. * Demonstration of the effects of piscivorous fish on tilapia production.
Aquaculture Systems Modeling	* To analyze and synthesize research results into models which better describe system processes.	* Models demonstrate the state of our current understanding of systems and system processes and provide direction for further inquiries.	* Improved representation of systems processes.	* Simulations which adequately describe biophysical processes in ponds.
New Aquaculture Systems/New Species	* To develop alternative aquaculture systems through the use of new or underutilized resources or through resource partitioning. * To develop culture systems for local and native species.	* Production can be tailored to local conditions through diversification of aquaculture systems.	* Development of production procedures for new species, combinations of species and/or the establishment of new aquaculture systems.	* Foundation for the use of other species and/or new species combinations in pond aquaculture.

TABLE 3. RESULTS FRAMEWORK FOR RESEARCH THEMES WITHIN THE ENVIRONMENTAL EFFECTS PD/A CRSP RESEARCH AREA.

ENVIRONMENTAL EFFECTS				
RESEARCH THEME	OBJECTIVE	CAUSAL ASSUMPTIONS	MEASURE	TARGET
Effluents	* To improve effluent water quality and water use efficiency.	* Reduction of excess nutrient loads will lessen environmental impact.	* Reduced nutrient loading.	* Demonstration of the effectiveness of CRSP guidelines to reduce effluent load.
Appropriate Technology	* To develop socially acceptable and environmentally friendly aquaculture technologies.	* Modification of current practices, tools, and facilities will lessen environmental impact.	* Reduced resource use in socially acceptable ways.	* Development of innovative approaches which result in a reduction of pond inputs, energy and/or excessively intensive management practices.
Responsible Science Policy	* To develop policies and guidelines that will govern the CRSP's work with exotic species, pharmaceuticals, and biotechnology.	* Communication and cooperation between potential host countries and the CRSP will be facilitated by a codified set of guidelines.	* Improved interaction with host country researchers and government officials in the area of exotics/drugs.	* Faster processing of necessary paperwork by host country officials.
GIS: Planning, Policy, Global Data Analysis	* To analyze and synthesize existing information at local, national, and regional scales.	* Integrating tools are required to assess potential and impact of aquaculture operations at scales above individual ponds.	* Analysis tools to determine environmental effects of proposed aquaculture locations.	* Assembly of datasets containing relevant summaries of CRSP research and data.

TABLE 4. RESULTS FRAMEWORK FOR RESEARCH THEMES WITHIN THE SOCIAL AND ECONOMIC ASPECTS PD/A CRSP RESEARCH AREA.

SOCIAL AND ECONOMIC ASPECTS				
RESEARCH THEME	OBJECTIVE	CAUSAL ASSUMPTIONS	MEASURE	TARGET
Marketing and Economic Analysis	* To develop marketing strategies for aquacultural products based on analysis of markets.	* Financial success is dependent upon meeting market demands.	* Improved pricing of aquaculture products. * Improved sales of products. * Reduced risk of adopting CRSP pond management technologies	* Provision of information which (when applied) will allow the targeted aquaculture industry to access new markets and increase the volume of sold goods.
Adoption/Diffusion	* To identify barriers to the acceptance of new aquaculture technologies.	* Aquaculture technology will be adopted if the social, economic, and technological requirements of the local community are addressed. In order to create a successful aquaculture development, these requirements must be known by decision-makers.	* Successfully identified barriers to adoption of CRSP practices.	* Provision of guidance to extension workers to further increase acceptance of CRSP technologies in host countries.
Food Security	* To improve understanding of food security issues and their relationship to aquacultural practices.	* Extensive fish farming can successfully provide a source of necessary animal protein for the rural poor.	* Assessment of food security needs of the rural poor, and the impact of aquaculture on dietary intake of animal protein.	* Provision of information on nutritional status and needs of rural poor. * Assessment of technology transfer impact on rural poor.
Regional Analysis: Human-Environment Interactions	* To develop an information base of the effects of socio-economic conditions on the development of a local, national or regional aquaculture industry.	* Aquacultural development is often seriously constrained by the regulatory, social, and economic environment. These large-scale constraints must be known in order to implement a successful aquaculture development strategy.	* Improved understanding of the socio-economic conditions that constrain aquaculture development.	* Development of recommendations that enable host countries to establish a successful aquaculture development strategy.
Decision Support Systems	* To refine computer applications to assist planners and managers in the development of economically efficient production technologies.	* Profitability can be improved through computer exploration of the effects of different management strategies on pond production potential and economic performance.	* Increased use of DSS by target clientele.	* Delivery of completed DSS to CRSP researchers, in-country personnel, development agencies, U.S. producers and extension agents. * Positive feedback from DSS users.
Product Diversification	* To develop a range of aquaculture products.	* Consumption of aquaculture products will increase if consumers are given a variety of product options.	* Availability of new aquaculture products in local markets.	* Development of processes and guidelines for the production of new aquacultural products.

3.1 Summary of Research Activities

The *Continuation Plan 1996-2001* identified three areas of aquaculture production systems research that is further subdivided into research themes designed to address the factors constraining the development of sustainable aquaculture. The research outlined in the Eighth Work Plan includes nine of the 15 themes listed in the *Continuation Plan*. This report presents the past year's research on the following themes: pond dynamics, feeds and fertilizers, reproduction control, aquaculture systems modeling, marketing and economic analysis, adoption/diffusion, decision support systems, effluents and pollution, and new aquaculture systems and species.

Pond Dynamics studies included the continued development of a pond soil classification system that can be utilized across a diversity of sites. Additionally, the data collected to refine this delineation system for pond soils further contributes to the knowledge base regarding the chemical characteristics of soil profiles that can be used in developing a system of pond soil taxonomy used in traditional soil science.

Special Topics Research on feeds and fertilizers involved continued testing of the effects of feed protein content on the semi-intensive production of *Penaeus vannamei* in Honduras, the evaluation of supplementary diets for tilapia culture in North Vietnam, and the identification of low cost supplemental feeds for tilapia cage and pond culture in the Philippines.

Reproduction Control research focused on the development of androgenesis techniques for the monosex production of tilapia and the determination of the optimal treatment conditions for masculinizing Nile tilapia (*Oreochromis niloticus*) through immersion in 17α-methyldihydrotestosterone.

Aquaculture Systems Modeling research was directed at enhancing an integrated aquaculture/agriculture model to include relationships between carbon input and sediment quality in aquaculture pond dynamics. Research also led to the development of an aquaculture pond model designed to analyze environmental impacts through the prediction of temperature and dissolved oxygen in stratified fish ponds. Special Topics Research produced two bioenergetics growth models—one that simulates Nile tilapia growth in an integrated culture system and another that incorporates limiting nutrients and standing crop in its simulations of tilapia growth.

Within the Marketing and Economic Analysis theme, a "safety first" model that explicitly addresses risk factors has been developed to analyze the integration of CRSP-developed pond fertilization schemes into Honduran shrimp and tilapia farming systems. Impact and welfare analysis models were also designed so that the social and economic returns attributable to PD/A CRSP technologies can be determined.

Adoption/Diffusion research involved the development of a qualitative study designed to trace the career and educational pathways of students, either directly or indirectly funded by the PD/A CRSP, to determine how students have affected the transfer of CRSP technological and financial resources.

Decision Support Systems (DSS) research lead to the improvement of the user interface of POND© software. In addition, POND© was refined to enable users to compare production efficiencies at different levels of fertilization and feeding with feed types of varying moisture, protein, and energy content.

Studies in Thailand and Honduras sought to address the impacts of effluents associated with tilapia and shrimp culture, respectively. At the Asian Institute of Technology researchers assessed the amount of nitrogen, phosphorus, and solids discharged from pond waters and evaluated five fish harvest techniques to determine which would most effectively reduce the loading of nutrients and solids in effluent waters.

Since 1993, the PD/A CRSP has participated in a collaborative effort with the Honduran government, local and international educational institutions, and Honduran shrimp farmers to monitor estuary and embayment water quality of the Gulf of Fonseca. Data collected can be used to detect improvements or declines in water quality, formulate and validate numerical estuarine models to predict future estuarine environmental conditions, and estimate estuary carrying capacity by combining farm chemical budgets and estuarine fluid dynamics. These efforts are ongoing.

In Peru, the need to evaluate the aquaculture potential of local and native species and develop appropriate culture technologies has been identified. Currently PD/A CRSP researchers are rearing *Piaractus brachypomus* to contribute to the limited production technology data existing regarding Peruvian aquaculture species and culture technologies.

Abstracts presented here also report on research results from the Interim Work Plan, which covered the period from 1 September 1995 to 31 July 1996, in addition to Special Topics Research. Interim Work Plan research included the continued testing of an integrated rotational aquaculture system designed in Thailand and Special Topics Research involved the development of two bioenergetics growth models.

The abstracts in the following chapter are divided into two major sections: Global Research and Regional Research. Global Research covers cross-cutting research, while the Regional Research section presents investigations, including Special Topics Research, conducted at each Host Country field site in Central America, South America, East Africa, and Southeast Asia. Full technical reports are published in the companion volume, the 15th Annual Technical Report. Copies can be ordered from the Program Management Office in Corvallis, Oregon.

3.2 Abstracts of Technical Reports

Global Research

Pond Dynamics

Pond Soil Characteristics and Dynamics of Soil Organic Matter and Nutrients

Eighth Work Plan, Pond Dynamics Research 1 (PDR1)

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Abstract
The objective of this investigation was to further develop a system for classifying pond soils that will assist with aquaculture pond management. Soil cores were collected from ponds at the Asian Institute of Technology (AIT), Pathum Thani, Thailand; the El Carao National Fish Culture Center, Comayagua, Honduras; and the Granjas Marinas shrimp farm, San Bernardo, Honduras. Cores were separated into 2-cm long segments and subjected to physical and chemical analysis. Data on bulk density were used to separate core samples into the following horizons: surface, well-mixed layer with bulk density of 0.3 g cm^{-3} or less (S horizon); stable, mature sediment with bulk density between 0.31 and 0.7 g cm^{-3} (M horizon); transition layer with bulk density of 0.71 to 0.99 g cm^{-3}; and original, undisturbed pond soil with bulk density of 1.00 g cm^{-3} and above. The S horizon was not more than 2 cm thick in any of the ponds, and only the upper 1 or 2 mm layer of the S horizon was oxidized (S_O subhorizon). Wet soil pH in almost all core segments was between 7 and 8. Dry soil pH was lower than wet soil pH. Concentrations of total carbon did not exceed 2.35% in any of the core segments, and the highest carbon concentrations were in S and M horizons. Total nitrogen ranged from 0.04 to 0.29% and was highest in S and M horizons. The carbon:nitrogen ratios in the S and M horizons were between 7 and 15. Total sulfur concentrations ranged from 0.15 to 3.42%, and some core segments represented potential acid-sulfate soil material in ponds at AIT and El Carao. There was evidence of phosphorus and calcium accumulation in surface soil layers as a result of inputs of these elements through pond management. Magnesium, potassium, and sodium concentrations were higher in soils of brackish water ponds than in those of freshwater ponds because of inputs of these ions in brackish water. Iron, manganese, zinc, and copper concentrations in soils were not especially high at any of the locations.

Reproduction Control

Artificial Propagation of Nile Tilapia for Chromosome Manipulation

Eighth Work Plan, Reproduction Control Research 1B (RCR1B)

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Abstract
The objective of this study is to establish appropriate techniques for the androgenic production of YY male tilapia. This report discusses initial efforts in the collection of freshly ovulated eggs from Nile tilapia (*Oreochromis niloticus*) that are required in experiments to develop techniques for induction of androgenotes. Hormonally induced ovulation of tilapias has not been successful; however, under environmentally controlled conditions tilapias can be somewhat predictably spawned. Given suitable water temperature and a controlled photoperiod ovulation time for tilapia can be reasonably predicted. Aquarium spawning of the Nile tilapia was managed through photoperiod manipulation. Four to six females were stocked with one male in 550-l aquaria maintained at 26 ± 2˚C. Fish ovulated

from 9.5 to 13.5 h after the controlled light-on cycle of a 20L:4D photoperiod. Ten females were stripped for artificial fertilization experiments, but only five progeny groups developed to hatching. Eggs were collected, milt was expressed over the eggs, and water was added to initiate activation. Fertilized eggs were placed in 1-l upwelling incubation units at a controlled temperature (± 0.2˚C) two to three minutes post activation. The temperature-related development rate was examined to develop a tau (t_0) curve to be used in chromosome manipulation. The mean mitotic interval during early synchronous cleavage was between 73.5 and 30 minutes at 20.6 and 27.5˚C, respectively. The temperature-compensating index of development will be used to standardize the application of shock treatment.

Steroid Immersion for Masculinization of Tilapia

Eighth Work Plan, Reproduction Control Research 2 (RCR2) and 3 (RCR3)

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Abstract
The use of all-male populations increases the efficiency and feasibility of tilapia aquaculture. The objective of this study was to determine the efficacy of a short-term immersion procedure for masculinizing Nile tilapia (*Oreochromis niloticus*). Three experiments were conducted to test 1. the effects of 17α-methyldihydrotestosterone (MDHT) immersions at different stocking densities (33, 67, 100, or 200 fish l^{-1}) 2. the effects of single immersions (33 fish l^{-1}) in 500 mg l^{-1} MDHT at 280, 310, or 364 Celsius Temperature Units (CTU) and 3. the effects of 17α-methyltestosterone (MT) fed treatments (60 mg MT kg^{-1} of food for 28 days) versus immersion treatments of MT and another masculinizing androgen, trenbolone acetate (500 mg l^{-1}). A single immersion in 17α–methyl-dihydrotestosterone at 364 CTU (day 13 post fertilization at 28°C) was as effective as two immersions at 280 and 364 CTU in producing 80% male populations. In a population of fish with a female-biased sex ratio that was not masculinized by four weeks of feeding with 17α-methyltestosterone, two immersions in trenbolone acetate at 280 and 364 CTU produced over 90% males. These results suggest that immersion of tilapia in steroids is an effective alternative to dietary treatment with androgens for the purposes of sex inversion.

Marketing and Economic Analysis

Economic and Social Returns to Technology And Investment

Eighth Work Plan, Marketing and Economic Analysis Research 1 (MEAR1)

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Abstract
The objective of this two-year study is to develop estimates of social and economic returns attributable to PD/A CRSP technologies. Year one involved data collection and year two will involve analysis. Impact and welfare analysis models have been developed. Supply and demand equations will be estimated to develop estimates of consumer and producer surplus before and after technology adoption. From these estimates the net change in social welfare will be estimated. Survey instruments were developed to collect data on adoption of CRSP-developed technologies from shrimp and tilapia growers in Honduras. Data collection should be completed by December 1997. The survey data will be used in the analysis.

Risk Analysis of Pond Management Strategies

Eighth Work Plan, Marketing and Economic Analysis Research 2 (MEAR2)

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Abstract
The primary objective of this study is to analyze the integration of pond fertilization schemes into farming systems including explicit treatment of risk factors, by use of a "safety-first" model. A farmer's decision to adopt a new technology will depend upon many factors that range from simple costs and returns to market factors and complex interactions between the new technology and the farming system practiced by the farmer. Survey instruments have been designed and are currently under review. They will be used to collect key production and price risk data on the variation in shrimp and tilapia production in Honduras. Data collection should be completed by December 1997.

Decision Support Systems

Advances in the POND© Software: Wizard Development and Model Refinements

Eighth Work Plan, Decision Support Systems Research 1A, 1B, and 1D (DSSR1A, 1B, and 1D)

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Abstract
To enable users to compare the production efficiency of pond culture systems receiving different levels of fertilization, alternate feed types (differing in moisture, protein, and energy contents), and various feeding levels, considerable refinements have been made to the POND© software in terms of its decision support capabilities and systems models. To improve the user interface and provide better support for decision-making, a series of "wizards" has been implemented. The wizards assist users to set up ponds and lots, generate liming and fertilization guidelines, produce optimal feeding schedules, and simplify the steps required to perform simulations under different conditions. POND© software model refinements during the current reporting period also include methods that account for the effects of fertilization, high fish biomass, feed types, and feeding levels on fish growth. Simulation results of the refined fish bioenergetics model (POND© Version 4.0) for common carp (*Cyprinus carpio)* and the African catfish (*Clarias gariepinus*) and progress on the development of models for phosphorus flux and polyculture interactions in ponds are discussed. Additionally, descriptions of two research efforts that commenced in the area of macrolevel agroecological system analysis are provided: 1. the development of POND© software capabilities to simulate integrated farming systems and 2. the integration of POND© fish growth and water temperature models within a Geographical Information System (GIS) that will also include economic and production factors to assess aquaculture potential in Africa.

Application of Systems Models for Evaluation and Optimization of Pond Management Practices

Eighth Work Plan, Decision Support Systems Research 1C (DSSR1C)

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Abstract
A comparative analysis of the production efficiency of pond systems managed using different PD/A CRSP fertilization strategies at three locations (Honduras, the Philippines, and Thailand) was

undertaken. Fertilization rates recommended by PONDCLASS© (a responsive fertilization strategy) were three to seven times more efficient in terms of phosphorus (P) recovery in fish flesh compared to fixed input strategies that are typically used at these sites. Nitrogen (N) recovery was in general comparable to or somewhat higher than that obtained in fixed input strategies. Net fish yields for the fixed input treatments were in general higher than those for the PONDCLASS© treatments; however the cost efficiency (in terms of fertilization costs per unit of fish produced) for the PONDCLASS© treatment was 1.5 to 3 times higher than the fixed input strategy for experiments conducted in the Philippines and Thailand. In Honduras, cost efficiency was comparable for the fixed input and PONDCLASS© treatments. This analysis suggests that current fixed input rates particularly for P at CRSP sites can be reduced without compromising production efficiency. Drawbacks of responsive fertilization strategies, such as the need for water quality analysis and adjustment of fertilization rates for individual ponds, are discussed.

For semi-intensive pond aquaculture, feeds are often the dominant component of the variable cost of fish production. Therefore, developing optimal feeding schedules that minimize feed use is important. An adaptive, non-linear search strategy has been implemented in the POND© software that enables users to generate optimal feeding schedules for individual ponds. Example simulations indicate that although such schedules result in lower feed requirements, fish tend to be cultured for longer time periods compared to satiation feeding (100 d). The cost of holding fish for a longer period may need to be accounted for in order to generate feeding schedules that are economically optimal. This area will be explored in future work on the optimization of pond production techniques.

Aquaculture Systems Modeling

Aquaculture Pond Modeling for the Analysis of Environmental Impacts and Integration with Agriculture: Relationship Between Carbon Input and Sediment Quality in Aquaculture Ponds

Eighth Work Plan, Aquaculture Systems Modeling Research 1A (ASMR1A)

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Abstract
The objective of this study was to develop a computer model which can be used to analyze and predict nitrogen and organic matter flows in aquaculture ponds. Previous improvements made to the integrated aquaculture/agriculture model include:

1. consideration of organic matter and nitrogen transformations;
2. modification of the fish growth model to include the effects of low quality feed on fish growth;
3. inclusion of sediments in mass balance calculations; and
4. coupling of the agriculture component and the aquaculture pond ecosystem model.

Further improvements to the model focused on:

1. the incorporation of sediment mineral processes;
2. the calculation of the carbon to nitrogen ratio in the water column; and
3. the modeling of the light extinction coefficient in ponds with high non-algal turbidity.

The modeling of the agriculture component processes and the relationship between the soil-terrestrial crop submodels is also discussed. Simulation results for chlorophyll *a*, water column total ammonia nitrogen, sediment organic matter, and total nitrogen are presented. The refinements

made to the model suggest that accuracy in the simulation of organic matter and nitrogen improves with an increase in the level of detail of the water column and sediment process equations.

Aquaculture Pond Modeling for the Analysis of Environmental Impacts and Integration with Agriculture: Modeling of Temperature , Dissolved Oxygen, and Fish Growth Rate in Stratified Ponds Using Stochastic Input Variables

Eighth Work Plan, Aquaculture Systems Modeling Research 1B (ASMR1B)

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Abstract
A model has been developed to predict water temperature, dissolved oxygen (DO), and fish growth in stratified fish ponds using stochastic weather variables. In the past year two model components were modified: phytoplankton respiration and organic matter decomposition, and two new components were added: the abilities to account for pond water exchange and multiple feed supplies. The model was tested using data from the PD/A CRSP Rwanda site. Simulation results are presented including water temperature, DO, individual fish weight, ammonia concentration, and chlorophyll *a* concentration.

Adoption/Diffusion

Assessing the Human Capital Impacts of the PD/A CRSP: A Conceptual Framework

Eighth Work Plan, Adoption and Diffusion Research 1 (ADR1)

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Abstract
This qualitative study will assess the human capital impacts of the Global Experiment in terms of training, advancement, and the technology transfer of developing-country nationals affiliated with PD/A CRSP research sites. The PD/A CRSP seeks to promote aquaculture through research and extension services in certain countries. One aspect of this program is the support of students in aquaculture programs. This report summarizes some considerations related to the backgrounds of these students, their career paths after degree completion, and the connections of these experiences to subsequent involvement in the aquaculture sector.

Regional Research

Central America

Effect of Diet Protein on Semi-Intensive Production of *Penaeus vannamei* during the Rainy Season

Interim Work Plan, Honduras Study 1 (Part Ia)

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Auburn, USA

John Wigglesworth, Hector Corrales, and Rafael Zelaya
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Choluteca, Honduras

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Abstract
The objective of this study was to determine the effect of dietary protein on shrimp growth and yield. The effects of four commercially-produced feed protein levels (12, 16, 20 and 30%) were tested during the semi-intensive production of *Penaeus vannamei.* Shrimp were cultured in sixteen 2-ha earthen ponds during a 110-day study. Ponds were stocked at 25 post-larval shrimp m^{-2}. Shrimp survival did not differ significantly among treatments and overall was much lower than expected because of Taura Syndrome. Feed protein level did not significantly affect gross yield, mean shrimp weight, feed conversion ratio, or shrimp growth. Similar quantities of feed were offered in all treatments; however, total nitrogen added to ponds (in the form of feed) increased significantly with feed protein content. Mean material exchange was negative (i.e., net discharge) for total nitrogen, total phosphorus, soluble reactive phosphorus, and chlorophyll *a* and BOD_2 . Greater amounts of total ammonia-nitrogen and nitrate-nitrite-nitrogen were taken into ponds than were discharged. There were no significant differences in material exchange among treatments.

Estuarine Water Quality Monitoring and Estuarine Carrying Capacity

Eighth Work Plan, Honduras Research 2 (HR2)

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Abstract
Water quality was monitored in major estuaries of Honduras affected by shrimp farming. Data collected will be added to baseline data established in 1993 and will be used to detect the deterioration or improvement of water quality and formulate and validate numerical estuary models. Samples were collected from 29 sites comprising 12 estuaries and embayments of the Gulf of Fonseca and the Choluteca River at La Lujosa and water quality was determined every one to two weeks. These data were added to baseline data that was established in 1993 to monitor long-term effects of shrimp farming on inlet water quality. Water quality continued to vary seasonally in estuaries directly influenced by riverine discharge. Nutrients concentrate during the dry season when there is little freshwater input and are diluted with rainwater discharge during the wet season. Embayment water quality was less seasonally variable and considerably less nutrient-enriched than riverine estuaries. No trends of long-term nutrient enrichment were detected in estuaries or embayments during the period of 1993 to 1997. Riverine estuaries are flushed annually during the wet season and embayments experience sufficient water exchange with the Gulf of Fonseca to effectively eliminate nutrient buildup.

On-farm Shrimp (*Penaeus vannamei*) Production Trials during the Rainy Season

Honduras Special Topics Research

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Abstract
The effect of geographic variation on shrimp growth, yield, and survival in ponds all managed similarly was evaluated in 0.3- to 2.3-ha earthen ponds located on four different commercial farms in southern Honduras. Ponds were stocked with hatchery spawned post-larval *P. vannamei* at 250,000 PL ha^{-1} (25 PL m^{-2}) from the same production run. Shrimp were fed a 30% protein commercial ration. Ponds were harvested after 110 days. Shrimp survival did not differ significantly among treatments, but was much lower than expected because of Taura Syndrome. Gross shrimp yields were low and ranged from 120 to 325 kg ha^{-1}. Shrimp yield increased significantly with increased survival ($r^2 = 0.885$, $P < 0.001$), while average individual weight decreased significantly with increased survival ($r^2 = 0.263$, $P < 0.05$). Total nitrogen, total ammonia-nitrogen, total phosphorus, and soluble reactive phosphorus concentrations did not differ significantly between pond intake and discharge water on individual farms. Among farms, chlorophyll *a* and BOD_2 concentrations in pond water were independent of total ammonia-nitrogen concentration ($r^2 = 0.034$, $P = 0.509$ and $r^2 = 0.006$, $P = 0.789$, respectively) and soluble reactive phosphorus concentration ($r^2 = 0.005$, $P = 0.800$ and $r^2 = 0.010$, $P = 0.726$, respectively).

South America

Development of Sustainable Pond Aquaculture Practices for *Piaractus brachypomus* in the Peruvian Amazon

Eighth Work Plan, Peru Research 1 (PR1)

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Abstract
To compare survival, growth, standing crop at harvest, condition, feed conversion, and cost of production fingerling paco (*Piaractus brachypomus*) are being reared at two densities (3,000 and 4,000 fish ha^{-1}) in six earthen ponds ranging from 1,015 to 5,320 m^2 in size in Iquitos, Peru. Fish are being fed 3% of their wet body weight daily using a locally-manufactured feed (approximately 30% crude protein). Production trials commenced 29 April 1997. Data are not yet sufficient for making treatment comparisons; however, data for water quality variables (hardness, dissolved oxygen, temperature, conductivity, ammonia-nitrogen, carbon dioxide, pH, alkalinity, nitrite-nitrogen, and nitrate-nitrogen) and production data are presented in this report. Pond soil and water samples have been collected and sent to Auburn University for detailed analyses. Pond construction and production data for Iquitos are being collected.

East Africa

New Site Development and Characterization

Eighth Work Plan, Kenya Research 1 (KR1)

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Abstract
The resident researcher arrived at the Sagana Fish Culture Farm on 31 March 1997 and pond renovation was begun on 10 April. Four of the farm's one-acre ponds were split into twelve experimental ponds and five fingerling production ponds. Activities to complete renovation through July 1997 included drain pipe installation, inlet reinforcement, and planting grass on levees. Several of the renovated ponds still require some excavation to ensure that depths and bottom contours are uniform among all experimental ponds. Each of the new experimental ponds will have a surface area of 800 m^2 and minimum and maximum water depths of 60 and 100 cm, respectively. The ponds have sufficient freeboard so that water levels may be raised to achieve maximum depths of 120 cm and surface areas of 825 m^2. Part of the earthen main water supply canal was lined with concrete.

Four of the farm's quarter-acre ponds were put into production after an extended period of disuse. Site development and characterization activities to be completed through September and October 1997 include: upgrading the chemistry laboratory; obtaining laboratory, farm, and office supplies, a datalogger system, and a four-wheel-drive vehicle; and characterizing the site in terms of soil, water, and climatic attributes.

Strain Variations in Sex Ratio Inheritance

Eighth Work Plan, Kenya Research 2 (KR2)

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Abstract
The sex ratio of individual spawns has been studied in only a limited number of strains of *Oreochromis niloticus*. Although *O. niloticus* females are thought to be homogametic and males heterogametic, progeny of single pair spawns have not conformed to the expected 50:50 sex ratio inheritance. The variance in *O. niloticus* sex ratio inheritance may be related to strain differences. Pair spawning and grow-out of the Turkana strain of Nile tilapia *(O. niloticus vulcani)* is being conducted at the Sagana Fish Culture Farm. This strain originated from a stock isolated in a crater lake on an island in Lake Turkana, Northern Kenya.

In the current study, the sex ratio of each set of progeny with a minimum of 100 fish will be determined though gonadal examination. Spawning hapas were constructed and stocked between three and five times between February and June, 1997. When water temperatures were less than 24 °C, females were often killed by males. Bird predation on brood fish also contributed to losses. Of the five spawns obtained, survival of fry was very low, due to predation from insects, and no spawns resulted in fry numbers greater than 30. More spawning hapas will be constructed and protection against predators will be enhanced to obtain improved spawning results. Sex ratio data from each spawn will be analyzed by Chi square to determine whether it differs from the expected 50:50 inheritance. This research is carried out in conjunction with the study "Monosex Tilapia Production Through Androgenesis." For further description of the study see the Global Research section of this report.

Nutritional Contribution of Natural and Supplemental Foods for Nile Tilapia: Stable Carbon Isotope Analysis (Effect of Preservation Method on Stable Carbon Isotope Ratios of Plankton and Tilapia)

Eighth Work Plan, Kenya Research 3A (KR3A)

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Abstract
Stable carbon isotopic analysis will be used to obtain quantitative estimates of the contribution of natural and supplemental feeds to the nutrition of tilapia in ponds at the Sagana site, Kenya, Africa. This will be accomplished by tracking the carbon isotopic "signatures" of tilapia and their known and probable food sources. Prior to analysis of samples from the experiment in Kenya, a pilot study was conducted at the University of Arkansas at Pine Bluff to determine whether different methods of sample preservation (formalin and alcohol or lyophilization) would affect the carbon isotope ratios of fish and plankton differently. Fish (*Oreochromis niloticus*) and plankton samples were collected from ponds in Arkansas. Each sample was divided into two halves. One half of each sample was subjected to fixation in formalin, followed by storage in alcohol. The second half was freeze-dried. All preserved samples were sent to a commercial laboratory (Coastal Science Laboratories, Inc.) for stable carbon isotope analysis. The carbon isotopic ratio of plankton preserved by formalin and alcohol was significantly different from that of plankton preserved by freeze-drying. Results did not differ for tilapia tissue preserved in formalin and alcohol versus freeze-drying. From the standpoint of isotopic analysis, either method of preservation would be suitable for further use in this study because the magnitude of the preservation effect was small compared to the trophic enrichment (diet) effect expected over the experimental period. However, freeze-drying is preferred because noxious chemicals are not used, samples do not have to be shipped in liquid (which reduces weight and shipping costs), and because the variability in isotope ratios of freeze-dried samples was slightly lower than that of formalin and alcohol-preserved samples.

Southeast Asia

A Finishing System for Large Tilapia

Interim Work Plan, Thailand Activity 4

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Abstract
This report presents the results of two experiments. A 90-day experiment was conducted to determine the appropriate biomass of caged tilapia cultured in earthen ponds that is required to support maximum production of small tilapia in open water while maintaining acceptable pond water quality. An 84-day experiment investigated the effects of aeration on the growth performance of both caged and open-pond tilapia and on water quality. Large tilapia (91 ± 5.2 to 103 ± 4.6 g) were stocked in 4-m^3 net cages at 50 fish m^{-3}. One, two, three or four cages were suspended in each earthen pond (three replicates per treatment). Tilapia fingerlings (13 ± 0.3 to 16 ± 1.3 g) were stocked at two fish m^{-3} in the open water of all ponds. Caged tilapia were fed commercial floating pellets; open-pond tilapia were solely dependent on the uneaten pelleted feed and natural foods derived from cage wastes. Water quality was analyzed biweekly. The biomass of caged tilapia had significant ($P < 0.05$) effects on the survival, growth, and feed conversion ratio of caged tilapia and also on the survival and growth of open-pond tilapia. Survival of caged tilapia decreased from 100 ± 0.0% to 76.8 ± 15.9% with an increase in their biomass (number of cages per pond); however, survival of open-pond tilapia was significantly lower in the one-cage treatment (89.7 ± 2.2%) than in the two- and three-cage treatments (94.6% ± 2.4% and 95.5 ± 1.1%, respectively). The mean weight of

tilapia harvested from cages decreased significantly from 478 ± 34.6 g in the one-cage treatment to 280 ± 32.0 g in the three-cage treatment. However, the growth of open-pond tilapia, ranging from 0.72 ± 0.03 to 1.27 ± 0.07 g $fish^{-1}$ d^{-1} increased significantly with the increased biomass of caged tilapia. The total net yield in this integrated culture system was highest (4.83 ± 0.03 t ha^{-1} $crop^{-1}$) in the two-cage treatment which had an overall feed conversion ratio of 1.00 ± 0.03. Nighttime aeration enhanced the growth performance of caged tilapia (net yield of 6.93 ± 1.03 t ha^{-1} $crop^{-1}$ compared to 3.65 ± 0.30 t ha^{-1} $crop^{-1}$) and increased the overall carrying capacity of the system. However, the growth of open-pond tilapia in aerated ponds was significantly lower than in non-aerated ponds.

Management to Minimize the Environmental Impacts of Pond Draining

Eighth Work Plan, Thailand Research 3 (TR3)

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Abstract
The objectives of this study were 1. to evaluate the amount of nitrogen, phosphorus, and solids discharged from aquaculture ponds during harvest draining; and 2. to assess fish harvest techniques that may reduce the loading of nutrients and solids in effluent water. Nile tilapia (*Oreochromis niloticus*) (initial size 103 ± 1 g) were cultured for 113 to 119 days in 15 earthen ponds of 200 m^2 size. Fish were supplementally fed with 30% crude protein feed at 50% satiation level in a fertilized pond system. Five pond harvest/draining procedures were followed: fish were anesthetized with tea seed cake (10 ppm) and the ponds seined three times—ponds were not drained (A); ponds were limed, completely drained and fish were collected from a harvesting pit (B); ponds were completely drained and fish were collected from a harvesting pit (C); ponds were drawn down to 50 cm, fish were harvested by two seinings, followed by complete draining and collection from a harvesting pit (D); and similar to D, but water was drained into the empty ponds of D (E). The mean fish size at harvest was 528 ± 8 g. The total harvest using procedure A was 97 ± 1% of the total fish in ponds; 76 ± 5, 14 ± 4, and 6 ± 1 % were harvested in the first, second, and third seinings respectively. Water quality was measured in column samples taken from undrained ponds and compared with effluent water quality at depths of 100-50 cm, 50-25 cm, and 25-0 cm from drained ponds. The waste discharged into receiving water was calculated for treatments B, C, D, and E. With the exception of total nitrogen, the effluent parameters measured (BOD_5, settleable matter, total solids, total volatile solids, total suspended solids, volatile suspended solids, and total phosphorus) occurred at higher levels in pond effluent water than was recorded in the water column of undrained ponds. Effluent values tended to increase as the pump position in the water column was lowered. Harvesting fish by seining, mid-way through pond drainage, also tended to increase the waste content of effluent water drawn from ponds, after seining, when compared with effluents of ponds which were drained without seine netting. Alternative fish harvest methods that minimize environmental impacts of pond draining are discussed.

A Bionergetics Growth Model for Nile tilapia (*Oreochromis niloticus*) based on Limiting Nutrients and Fish Standing Crop in Fertilized Ponds

Thailand Special Topics Research 1

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Abstract
A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) in fertilized ponds was developed, which linked Nile tilapia growth with limiting nutrients in pond water. The model incorporated five key variables affecting growth in fertilized ponds: body size, temperature, dissolved oxygen, unionized ammonia, and food availability. In the model, food availability was estimated by a relative feeding level parameter, which was a function of potential net primary productivity based on limiting nutrients and standing crop for Nile tilapia. The model was validated using growth data for Nile tilapia in 30 fertilized ponds and successfully detected growth variations among ponds receiving the same nitrogen and phosphorus inputs. The model described 89% of the variance in growth in these ponds. The relationship between predicted and observed growth rates had a slope of 1.02 and an intercept of -0.17, not significantly different from 1 and 0, respectively. The model indicated growth variations that were caused by carbon limiting primary production during 55 to 99% of the culture period. Sensitivity analysis indicated that the parameters related to net energy from feeding were more sensitive than those related to fasting catabolism. Growth was most sensitive to food availability when DO was above its critical limit (1.0 mg l^{-1}) and was most sensitive to DO when it was below the critical limit.

A Bioenergetics Growth Model for Nile Tilapia (*Oreochromis niloticus*) in a Cage-Cum-Pond Integrated Culture System

Thailand Special Topics Research 2

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Abstract
A bioenergetics model was developed to simulate growth of both caged and open-pond Nile tilapia in a cage-cum-pond integrated culture system. Five key variables affecting Nile tilapia growth—body size, temperature, dissolved oxygen, unionized ammonia and food availability—were incorporated in the model. Caged tilapia were given artificial feed, while open-pond tilapia were dependent on uneaten feed left by caged tilapia and natural foods derived from cage wastes. In the model, availability of natural foods was estimated by a relative feeding level parameter, which was a function of potential net primary productivity based on fish standing crop and limiting nutrients in ponds. The model was validated using growth data of both caged and open-pond tilapia in 28 ponds. The model described 95% and 83% of the variance in growth of caged and open-pond tilapia, respectively. Statistical analyses indicated there were agreements between predicted and observed values for both caged and open-pond tilapia. The model showed that, when the total number of tilapia stocked in cages was not greater than 200 fish $pond^{-1}$, the growth of open-pond tilapia was limited by the amount of phosphorus available to primary production. When more than 200 fish $pond^{-1}$ were stocked, phosphorus was initially the limiting nutrient but this later shifted to nitrogen. Nitrogen limitation increased from 0 to 84.4% of the culture period with increases of artificial feed inputs. The model revealed that nitrogen from biological nitrogen fixation accounted for 44.2 to 74.8% of the total nitrogen available for primary production. Under the model assumptions, pelleted feed accounted for only 13.8 to 14.6% of the growth of

open-pond tilapia when dissolved oxygen was above the critical limit (1.2 mg l^{-1}) for caged tilapia during the entire experimental period; however, the percentages ranged from 19.0 to 51.0% when dissolved oxygen was below this critical limit. Sensitivity analysis showed that parameters for caged tilapia affected growth of open-pond tilapia but not the reverse. Poor water quality (low dissolved oxygen and high unionized ammonia) further reduced the growth of caged tilapia, but increased the growth of open-pond tilapia.

Evaluation of Low Cost Supplemental Diets for Culture of *Oreochromis Niloticus* (L.) in North Vietnam (Part I)—Formulation of Supplemental Diets

Thailand Special Topics Research 3

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Abstract
An experiment was conducted to determine the feasibility of nine low-cost, formulated diets for Nile tilapia culture in North Vietnam. The first seven diets (TI-T7) containing 20% crude protein were formulated from locally-available ingredients such as concentrated chicken feeds, fish meal, rice bran, corn meal, and cassava meal. The two additional baseline diets (T8 and T9) used only rice bran or corn meal. All male, sex-reversed tilapia fingerlings with a mean weight of 8.4 g and stocked at 25 fish m^{-3} were cultured in net cages suspended in a 1,000-m^2 earthen pond. The pond was fertilized with urea and superphosphate at a rate of 28 kg N and 7 kg P ha^{-1} wk^{-1}. At initial stocking fish were fed 15% body weight per day which was gradually reduced to 3% body weight per day in accordance with fish growth over a 90-day culture period. Results showed significant differences among the experimental diets in fish growth rate, fish production, and feed conversion ratio (FCR) ($P < 0.01$), but results were not significant for survival rate and protein content of harvested fish carcasses. The 20% crude protein diet formulated from concentrated chicken feed (40% crude protein) and cassava meal (T3) resulted in the highest growth rate and yield. Daily weight gain for this treatment was 1.91 g $fish^{-1}$, production was 4.17 kg m^{-3}; and FCR was 1.64. Economic comparison showed that this diet also resulted in the highest profit (US$ 0.34 kg^{-1} fish produced), which is approximately 11 times higher than the profit from the diet consisting solely of rice bran. Total feed investment per unit of area cultured for the T3 diet was relatively high but the break even price for 1 kg of fish produced was lowest (US$ 0.76 kg^{-1} fish) due to high fish production. The treatments with diets formulated from fish meal and cassava meal (T6), fish meal and corn meal (T5), and concentrated chicken feed and rice bran (T4) had intermediate fish growth and fish yields and relatively high net profits. These results suggest that these diets present alternatives for farmers who require a relatively high net profit, but at a lower feed investment cost per unit area cultured. The sole use of either rice bran or corn meal for tilapia feeding resulted not only in low fish production and low profit but also in low returns to investment and high break even prices.

This study was not funded using CRSP core funds.

Development of Low Cost Supplemental Feeds for Tilapia in Pond and Cage Culture in the Philippines

Eighth Work Plan, Philippines Research 1 (PHR1)

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Abstract
A two-phase study will examine the use of yeast and composted rice straw as potential ingredients of supplemental feeds for tilapia (*Oreochromis niloticus*) and assess the effectiveness of compression pelleting technology in comparison with feeds processed using meat grinding equipment. Phase one will test two experimental diets—a 60% rice, 15% yeast, 25% meat and bone meal diet and a 60% rice bran, 15% composted rice straw, 25% meat and bone meal diet—in 12,500-m^2 earthen ponds. Ponds were stocked at three fingerlings m^{-2} and received weekly nutrient inputs (1.625 kg of ammonium phosphate [16-20-0] and 1.1 kg of urea ammonium phosphate [45-0-0]). Tilapia were fed the experimental diets at 5% BWD for the first two months of the experiment and 3% BWD for the final month until harvest. Fertilization of experimental ponds was discontinued at initiation of feeding. Preliminary water quality results of the phase one experiment are presented in this report. The phase two experiment will test rice straw compost- and yeast-based diets prepared with a pellet mill or a meat grinder in 20 units of 6-m^3 cages using a two x two factorial design.

4. Research Support

Preparation of the *Continuation Plan 1996-2001* entailed a review of current aquaculture literature and discussions with many aquaculturists to determine research needs and constraints to aquaculture development. In addition to limited knowledge of various aspects of production systems, lack of access to training and to information were found to restrict aquaculture development. In response to these needs, the program created research support as a separate building block of its proposed research activities. Research support activities build capacity through education, technology transfer, information management, and networking.

Educational Development, Central Database, and Information Management and Networking are the three branches of the CRSPs research support activities.

The annual activity reports for the Educational Development Component (EDC) and for Central Database are contained in Chapters 4.1 and 4.2 and are presented as prepared and submitted by their respective key project personnel.

Information Management and Networking, a component which is an integral part of program management and whose work is closely prescribed by the reporting requirements and timelines of the grant, reports on its own and on program-wide activities related to publications, networking, and impacts in Chapters 4.3 and 4.4.

4.1 Education Development

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Background

The Education Development Component (EDC) was established in response to the need to improve human capacity development, one of the constraints to aquaculture to be addressed by the CRSP during this grant. The goal of the EDC is to complement the research activities of all CRSP projects by strengthening human capacity in participating countries and regions. EDC began its first year of operation during this reporting period.

The EDC works with CRSP projects to design and implement appropriate training and education activities that support the research themes at each site. In addition to supporting site-specific activities, the EDC maintains a centralized clearinghouse for training and education opportunities in the fields of aquaculture, aquaculture development, aquatic ecology, fisheries, and natural resource management.

Education Advisory Panel—Honduras

The five-year plan for the EDC training program calls for concentration on one CRSP host country during each year, beginning with Honduras during 1997-98. In each participating CRSP country, an Education Advisory Panel will be organized to advise the EDC coordinator about education and training priorities in their country. During this period, an Education Advisory Panel was organized in Honduras, with representatives from the institutions most involved in aquaculture development in the region, including representatives of government, educational institutions, and private businesses. The EDC will use the Honduras panel as a model in establishing similar panels in the other countries where the PD/A CRSP collaborates and where human capacity development is a limiting factor in the growth of aquaculture.

At its first meeting in April 1997, the advisory panel identified long- and short-term education and training needs in Honduras. The panel agreed that in the long run, the Honduras aquaculture industry needs to develop the human capacity for research and research administration so that future aquaculture research stations can operate under the direction of Hondurans. The panel also identified short-term needs, such as technical training in production management and techniques and business management. The panel agreed that the short courses and workshops should eventually be self-supporting, using registration fees charged to participants.

Honduras panel members include:

Francisco Avalos, Executive Director, Asociacion Nacional de Acuicultores de Honduras (ANDAH),
Marco Polo Micheletti Bain, Vice-Minister, Secretaria de Agricultura y Ganaderia,
Medardo Galindo, Gerente General of the Federacion de Agroexportadores de Honduras (FPX),
Rosa Garcia, Director, Direccion General de Pesca y Acuacultura (DIGEPESCA),
Daniel Meyer, Head, Animal Sciences Department of Escuela Agricola Panamericana (EAP),
Marco Tulio Sarmiento, Chief, Aquaculture Department, DIGEPESCA,
Luis Morales, Chief, Research Department, DIGEPESCA,
Bartholomew Green, Co-Principal Investigator, PD/A CRSP Honduras project,
Alberto Zelaya, Gerente General, Asociacion Nacional de Acuicultores de Honduras (ANDAH).

The panel recommended that the EDC support a Honduran graduate student to study at a CRSP-affiliated university; during the next reporting period the first master's level student to be supported by the EDC will enter Auburn University. In response to short-term training needs, a workshop that addresses business plan development, aquacultural economics, and marketing of aquaculture products has been planned during this reporting period, and will be implemented in the fall of 1997. The Education Advisory Panel for the Philippines will be the next to be convened, with preliminary meetings taking place in the fall of 1997.

Educational Opportunities Network (EdOp Net)

In addition to supporting activities that address specific needs in CRSP host countries, the EDC works to facilitate communication about educational opportunities worldwide in aquaculture and related fields. During this reporting period, the EDC began publishing EdOp Net, a free monthly newsletter that summarizes educational and employment opportunities available in the field of aquaculture, aquatic ecology, fisheries, fisheries biology, and natural resource management. EdOp Net is disseminated through the mail and through the Internet by email and the World Wide Web. In less than a year, the number of subscriptions has climbed to over 200, and continues to grow each month. Reader surveys indicate that EdOp Net is considered useful to very useful by those who read it, who also indicate that they share their copy with an average of four other colleagues. During this reporting period, ten issues of EdOp Net were published.

ISTA IV

The PD/A CRSP is one of the sponsors of ISTA IV, the Fourth International Symposium on Tilapia in Aquaculture. During this reporting period, the EDC has served as the CRSP link to the Planning Committee ISTA IV, providing assistance in organizing and publicizing the meeting.

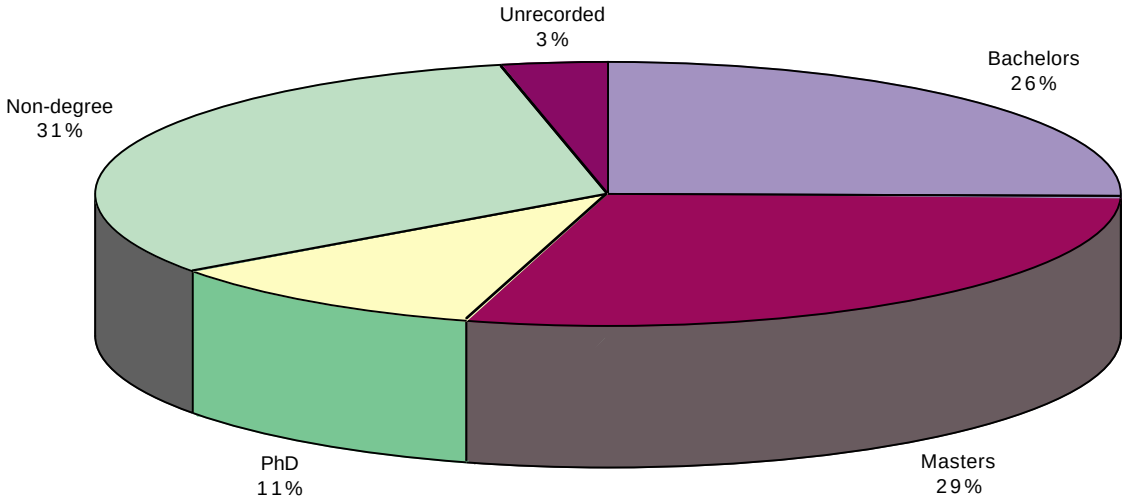
Eneida Ramírez, an Assistant Chemist at the La Lujosa Water Quality Laboratory in Choluteca, Honduras, was among the host country participants sponsored in part by the EDC to attend training courses and ISTA IV during a visit to the US.

Formal and Informal Training

The EDC maintains records of formal and informal training efforts conducted by CRSP researchers, and makes this information available to CRSP researchers as needed. CRSP researchers have long recognized that education and training help to address the constraints to sustainable aquaculture development, and take advantage of opportunities to conduct formal and informal training activities. They conduct short courses and workshops, teach courses at host country institutions, and advise and mentor graduate students. Even without formal financial support in the past, CRSP researchers have made significant contributions in the area of education and training.

Since the inception of the PD/A CRSP, over 500 individuals have participated in some form of CRSP education and training activities. Of those, 298 have been recorded officially as participants, and data has been collected. Figure 1 shows the distribution of degree and non-degree training among those officially registered as CRSP participants. This figure does not include students of CRSP researchers who teach post-secondary courses in aquaculture at their home institutions. During this reporting period, CRSP researchers taught the post-secondary aquaculture courses to almost 100 students at institutions in the US and Peru. Figure 2 shows the gender distribution of CRSP training participants since the inception of the program.

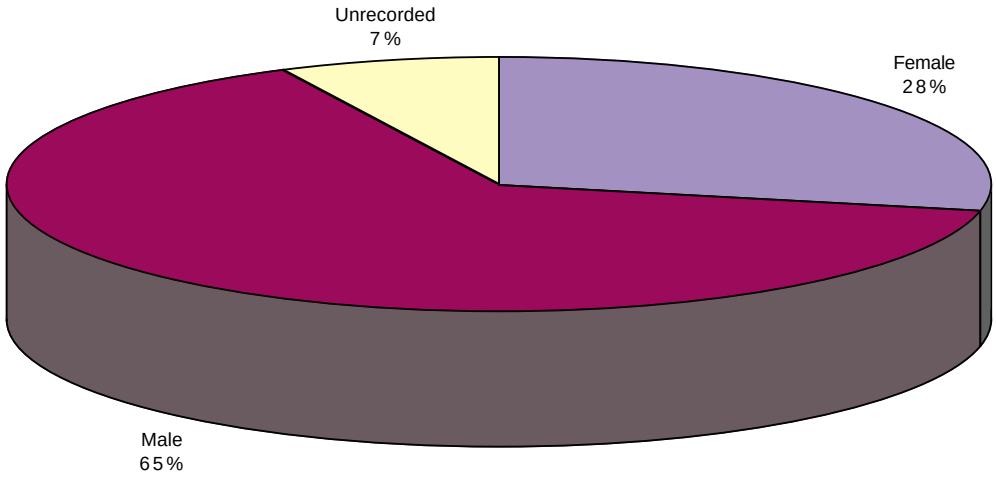
FIGURE 1. DISTRIBUTION OF PD/A CRSP DEGREE AND NON-DEGREE TRAINING, 1984-1997.



Even without dedicated education and training funds, CRSP researchers have found ways to support students who are pursuing higher education degrees in aquaculture and related fields. Support has included providing graduate research assistantships for Ph.D. students, hiring undergraduate work-study students, providing research materials, and advising students working on research projects. Prior to this reporting period, over 150 degrees (B.S., M.S., and Ph.D.) had been awarded to students receiving some level of CRSP support. During this reporting period, 11 formal degree programs were completed, and 42 were in progress. Since 1990, over 40 theses have been completed, including 8 senior theses, 30 Masters theses, and 3 Ph.D. theses. The following theses were completed this year with assistance from CRSP researchers:

Arifin, Z. 1996. Efficacy of liming and uses of liming materials for shrimp pond management. M.Sc. thesis, Asian Institute of Technology, Bangkok, Thailand.

Figure 2. Gender distribution of PD/A CRSP training participants, 1984-1997.



Barte, M. 1996. Effect of aeration on water quality and fish growth in intensive culture of Nile tilapia. M.Sc. thesis, Asian Institute of Technology, Bangkok, Thailand.

Gross, A. 1996. Effects of five phosphorus levels in "all plant" diets for channel catfish on water quality in ponds. M.S. thesis, Auburn University, Auburn, Alabama.

Nath, S. 1996. Development of a Decision Support System for Pond Aquaculture. Ph.D. dissertation, Oregon State University, Corvallis, Oregon.

Nguyen, P.H. 1996. Effects of salinity on fertilization for tilapia culture. M.Sc. thesis, Asian Institute of Technology, Bangkok, Thailand.

Ruttanagosrigit, W. 1997. Organic matter dynamics in a closed intensive culture system for black tiger prawn *(Penaeus monodon*). Ph.D. dissertation, Asian Institute of Technology, Bangkok, Thailand.

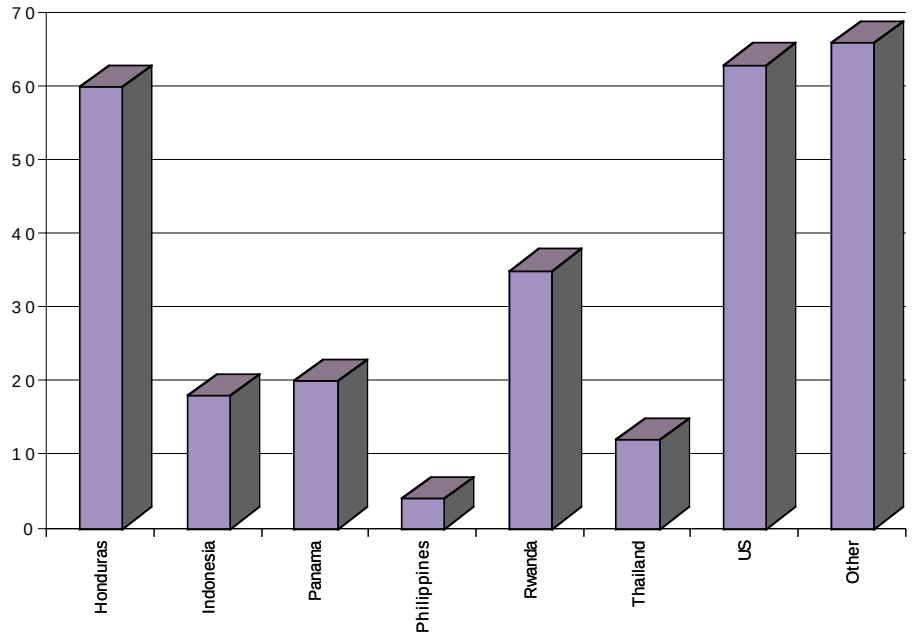
Sampson, M.H. 1997. Physico-chemical comparison of water from two estuaries in southern Honduras during the dry season. Senior thesis, Escuela Agricola Panamericana.

Thakur, D.P. 1996. Water quality and nutrient budget in closed intensive shrimp culture systems. M.Sc. thesis, Asian Institute of Technology, Bangkok, Thailand.

Most participants in CRSP education and training activities are from current or past CRSP host countries–Egypt, Honduras, Indonesia, Panama, the Philippines, Rwanda, Thailand, and the US; however, the benefits of CRSP training activities extend well beyond the borders

of these countries. Participants have been drawn from 33 countries over the course of the program, representing every region of the world (see Figure 3). Figure 4 represents the distribution of training participants at PD/A CRSP institutions, including PD/A CRSP research sites in host countries, since 1984.

FIGURE 3. HOME COUNTRIES OF PD/A CRSP TRAINING PARTICIPANTS, 1984-1997.

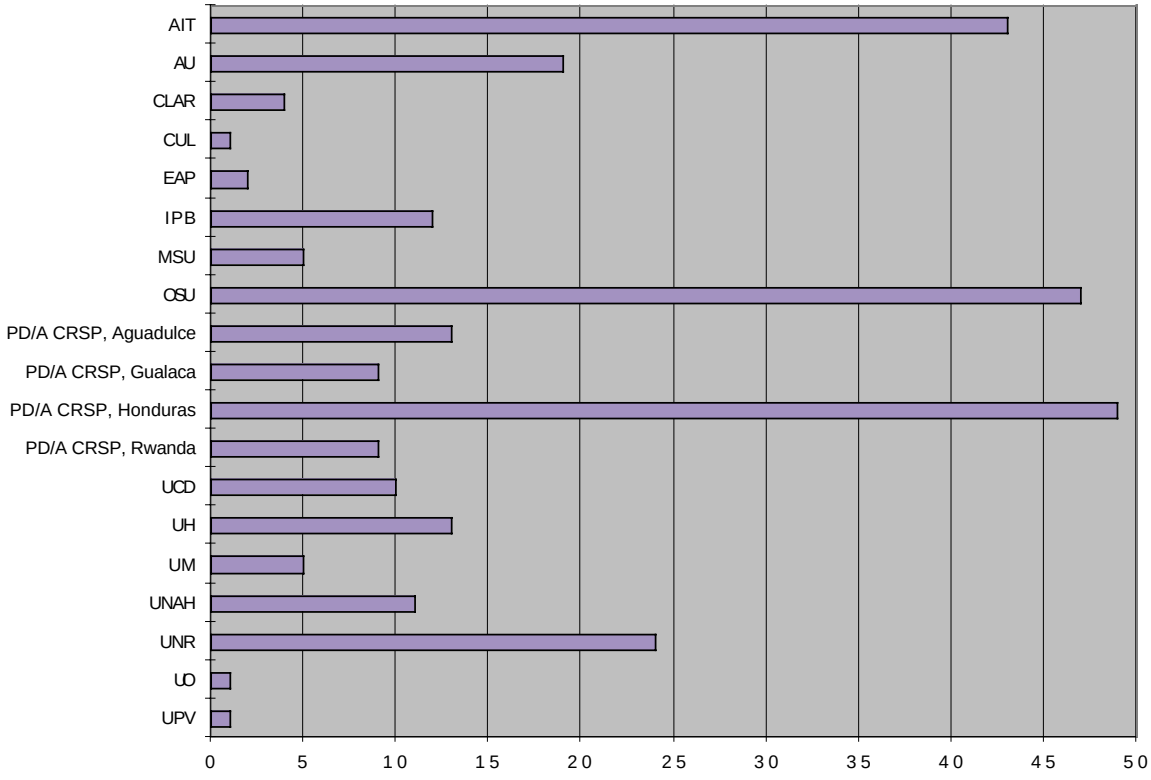


The interdisciplinary nature of aquacultural research attracts participants from a wide range of academic disciplines and professional positions. Many participants are able to apply their CRSP education or training directly to their work, or use the training they receive from the CRSP to begin new businesses. Luis Lopez, a former CRSP Research Assistant, currently works as a manager for Granjas Marinas in southern Honduras. Marco Iván Rodríguez, another former CRSP Research Assistant, started his own business, Palillos Fish Farm, to produce tilapia fingerlings and broodstock. In 1996 he produced half a million fingerlings, and expects to hit the one million mark in 1997. In addition to receiving high quality fingerlings and broodstock from Rodríguez, farmers also receive fish culture advice based on CRSP techniques. Other CRSP training participants have returned to positions in schools, agricultural research institutes, development projects, and agricultural extension services, where they are able to increase public awareness of aquaculture's importance in the food system.

In addition to degree training, post-secondary courses, short courses and workshops, CRSP researchers serve as a resource to a variety of governmental and non-governmental

organizations. In Thailand, CRSP researcher C. Kwei Lin provides advice on backyard catfish-tilapia integrated culture to the Christian Happy Home in Chiang Rai, and works with the Udorn Development Foundation and the FAO/Belgium project in Cambodia. He presented a workshop on the development and problems of marine shrimp culture in Asia for 50 people at the University of Agriculture and Forestry, Research Institute for Aquaculture in Ho Chi Minh City, Vietnam, and conducted a seminar sponsored by the Royal Thai Department of Fisheries for fisheries officers on trends of development and water use in freshwater aquaculture.

Figure 4. Distribution of training (degree and non-degree) participants at PD/A CRSP institutions, 1984-1997. (Please see Appendix A for an explanation of acronyms.)



4.2 Central Database Management

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Background

The PD/A CRSP Central Database is a centralized data storage and retrieval system for PD/A CRSP research and for other aquaculture research programs with compatible objectives and standardized methodology. The Database, started in 1983, currently contains over eighty aquaculture production studies and represents the world's largest inventory of standardized aquaculture data. Through its World Wide Web site, the Database is available to aquaculture researchers, educators, outreach and extension agents, and producers worldwide.

Two fundamental objectives for the original development of the Database were to 1) create a mechanism for analysis of variance among geographically dispersed aquaculture research sites, in addition to analyses within single ponds and among ponds at a single location, and 2) support development of predictive models for aquaculture pond processes (Egna et al., 1987). Ten years later, these objectives remain central to the purpose of the Database. Further discussion on the purpose and methods of the Database can be found in Batterson et al. (1991) and Ernst et al. (1997).

Objectives

The Database was relocated to Oregon State University in May 1996. Since then, objectives in the development and management of the Database have focused on procedures to promote error-free and timely data submissions from PD/A CRSP research projects and on the infrastructure and mechanisms necessary to support Database publication on the World Wide Web. These objectives include those originally stated in the Database Proposal (Eighth Work Plan) as well as priority issues that have emerged over the last year. These objectives were to:

1. Reconstruct the Database under a rigorous, relational framework.
2. Enter missing, overdue data for Workplans 1 through 7.
3. Add experiment protocol information to all existing datasets.
4. Develop a tracking mechanism for current PD/A CRSP research projects.
5. Publish a Database Manual for data submission requirements and methods.
6. Update and expand the PD/A CRSP Handbook of Analytical Methods.
7. Publish the Database on the World Wide Web.
8. Establish context-sensitive linkage between the Database and the Program Management Office Web Sites.
9. Enhance awareness of the Database in the greater aquaculture community and create additional opportunities for its use.

Rationale

Standardized methods for aquaculture research and standardized databases for aquaculture information are fundamental requirements for the continued advancement of aquaculture science and engineering. The PD/A CRSP is a world leader in both standardized methods and database publication of aquaculture research.

However, as of December 1996, the Database served mainly as a data repository for PD/A CRSP research projects with relatively few requests for data use (about 30 total from 1983 to 1996). This lack of use by the aquaculture community was likely due to a combination of factors, including lack of awareness, difficulties in database access, and lack of the necessary database infrastructure to facilitate the search and extraction of specific datasets. An additional problem with the Database was a continuing accumulation of overdue data submissions from PD/A CRSP research projects.

The objectives enumerated above directly address these concerns. The people who will benefit from this work, i.e. existing and potential users of the PD/A CRSP Database, include aquaculture researchers, educators, outreach and extension agents, and producers worldwide.

Objective 1: Database Reconstruction

Tasks. Reconstruct the Database under a relational organization framework. Find and remove all erroneous data. Implement procedures to prevent future entry of erroneous data.

Accomplishments. The new, hierarchical organization of the Database mirrors that of the PD/A CRSP program, including the various research facilities involved, the experiments performed at each of these facilities, and the treatment protocols and replicate data comprising each of these experiments (see diagram on p. 38). Five levels of hierarchical organization are used: 1) global, 2) facility, 3) experiment, 4) experiment treatment, and 5) treatment replicate. The relational-database software used to manage the database enforces these data relationships.

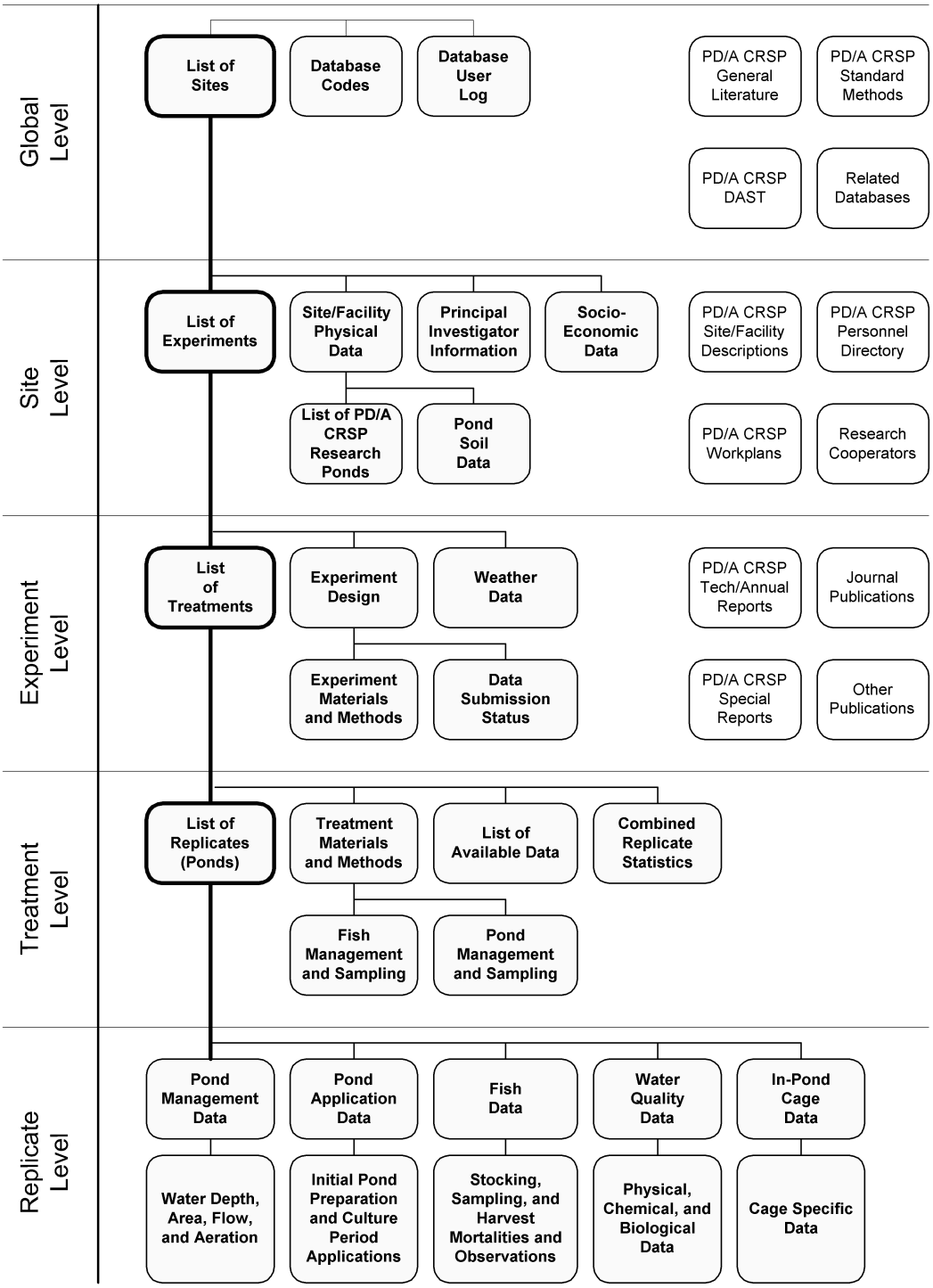
Considerable reorganization and editing of the database was required to remove erroneous data, implement relational data structures, and support efficient mechanisms for data access and publication. Some of these changes unfortunately required adjustments to data-table formats used by researchers. However, these changes were essential to the development of a database architecture that supported data-entry error checking and data-extraction user queries and graphical formatting.

The degree of work required under this objective, about three months total, was not anticipated in the Database Proposal (Eighth Work Plan). It was incorrectly assumed that the Database was already in a workable, relational, organization structure.

Specific accomplishments include:

- The Database has been reorganized from 720 files, maintained in dbf format using FoxPro database software, to one file (60 MB) maintained under Microsoft Access® database software.

THE NEW, HIERARCHICAL ORGANIZATION OF THE PD/A CRSP DATABASE MIRRORS THAT OF THE PROGRAM.



- Primary-key based data indexing and automated relational data organization has been implemented.
- Partial and fully duplicate records have been removed.
- Inconsistent pond names have been corrected.
- Redundant and undefined names for fish stocks and pond application materials have been corrected.
- Reorganization of time and depth of water samples to primary-key based indexing has been accomplished
- Removal of erroneous data values exceeding reasonable range values has been completed.

Objective 2: Overdue Data Submissions

Tasks. Enter missing, overdue data for Workplans 1 through 7. First, rely on Principal Investigators to come forward with overdue data until Dec. 1997. Then, generate a list of overdue data submissions, organized by Principal Investigators responsible, and pursue directed inquiries.

Accomplishments. Historically, submission of data from PD/A CRSP research projects to the Database has not been adequately enforced. As a result, for Workplans 1-7, approximately one-third of the total studies that should be in the database is missing. At the 1997 Annual Meeting, the Database Manager provided a list of experiments that were in the Database and asked that overdue data through the Seventh Work Plan (Sept. 1, 1993 to Aug. 31, 1995) be submitted. However, since May 1996, the Database Manager has received only one data submission from a PD/A CRSP research project.

To be completed. The next step to be completed is to generate a list of all overdue experiments, identified by Work Plan and Experiment Title and organized by Research Site and Principal Investigator. This list will be published and kept current at the Database Web Site, where it will be accessible to all past and current Principal Investigators. With this list as a reference, correspondence with Principal Investigators (copy Program Management Office) will be initiated regarding specific datasets due, their required content, and their anticipated timelines of completion.

Objective 3: Experiment Information for Existing Datasets

Tasks. Add experiment protocol information to all existing experiment data already submitted to the Database. Require this information for all future data submissions.

Accomplishments. For all PD/A CRSP studies submitted to the Database through May 1996 (80 total), data in the Database consisted of replicate sampling data only and lacked additional information regarding research protocols and experiment treatment specifications. With no information regarding fish pond management, there was a corresponding absence of a fish production-methodology context from which a database user could identify and extract specific datasets. The PD/A CRSP Workplans, Technical Reports, and Annual Reports were of limited use for defining treatment specifications in the

Database, especially after Work Plan 3, given their superset relationship to the Database subset, re-mixing of experiment treatments between proposals and reports, and lack of linking references.

To the greatest degree allowed, experiment treatment specifications have been gleaned from the Database itself by compiling fish stocking, pond application, and water management data into overall treatment values. These specifications are organized by Experiment ID (combines Work Plan, Site Code, and Experiment Number) and by the specific experimental replicates (Facility Ponds) assigned to that treatment.

All experiment and treatment information is now required at the time of data submission. As itemized in the Database Manual, this information includes research objectives, experimental design, sampling protocols, additional materials and methods not described in the PD/A CRSP Handbook of Analytical Methods, explanation of departures from planned protocols, and significant problems encountered in the course of the study.

The degree of work required under this objective was not anticipated in the Database Proposal (Eighth Work Plan).

To be completed. The next step to be completed is to circulate these specifications to individual Principal Investigators for review, correction, and additional information.

Objective 4: Data-Submission Tracking

Tasks. Develop a tracking mechanism for current PD/A CRSP research projects regarding required content and due-dates of data submissions.

Accomplishments. For the Eighth and subsequent Work Plans and greater, requirements for data submission to the Database are defined in the individual research sub-contracts (Article VII, Reporting Requirements) and in the Database Manual. All data collected under a study must be submitted within three months (90 days) of the scheduled end of an experiment. It is the responsibility of the Database Manager to circulate data submission reminders and overdue-notifications to the Program Management Office and Principal Investigators.

To effectively carry out this task, a Work Plan summary table is required that lists all research studies of each Work Plan organized by research site. Also included would be experiment start and end dates and a list of, or reference to, all data that are to be collected and submitted for each experiment. Given mutual benefits and complementary responsibilities, discussions with the Program Management Office have shown that this table would best be accomplished as a combined effort between the Database Manager and the Program Management Office.

To be completed. The next step to be completed is to build a template for this table and post it at the Database Web Site. The Program Management Office will enter Work Plan information into the table and keep it updated. The Database Manager will mark check-off boxes when data is correctly submitted and the Program Management Office will do the

same for other project deliverables. This list will be readily available to Principal Investigators, the Program Management Office, and the Database Manager at the Database Web Site.

Objective 5: Database Manual for Data Submissions

Tasks. Develop a Database Manual to provide a single source for all data submission requirements and procedures. Distribute manual to Principal Investigators.

Accomplishments. Procedures that must be considered by Principal Investigators to properly submit data to the Database include data-submission timeline requirements, data-submission mechanisms, personnel and publication referencing, site and facility specification, data organization, format, and use of templates, experiment and experiment-treatment specification, and description of departures from Work Plan protocols and standard methods. All of this information has been made available in the Database Manual, available in printed form from the Database Manager or in electronic form at the Database Web Site. The first version was completed January 1997 (Ernst, 1997).

To be completed. An updated version of the Database Manual is a high priority and will be completed by Sept. 1, 1997.

Objective 6: PD/A CRSP Handbook of Analytical Methods

Tasks. Update and expand the PD/A CRSP Handbook of Analytical Methods (Piedrahita et al., 1991). Establish direct, one-to-one linkages between the Handbook sampling variables and the Database data fields by use of common data (variable) names. Put the Handbook into the Database and make it available to PD/A CRSP research personnel and data users.

Accomplishments. At the 1997 Annual Meeting, the Materials and Methods Technical Subcommittee delegated responsibilities for method revisions (e.g. weather, soil, water, and fish sampling) and method additions (e.g. facility and experiment specifications and socio-economic data). The Database Manager was assigned the task of receiving and collating these updated methods, using the existing version of the Handbook as a starting point.

To be completed. An electronic form of the PD/A CRSP Handbook of Analytical Methods has been located and now needs to be added to the Database. As inputs from the Materials and Methods Technical Subcommittee come forward, methods in the Handbook will be updated.

The existing PD/A CRSP Handbook of Analytical Methods (Piedrahita et al., 1991) contains copyrighted materials used directly from external sources. To honor copyright agreements between these sources and the PD/A CRSP, copyrighted material will continue to be made available to PD/A CRSP researchers only. For public domain publication of the Handbook at the Database Web Site, copyrighted sections will be replaced with references. This public domain version of the Handbook will be useful to data users, as contextual information for specific studies, and to aquaculture research projects outside of the PD/A CRSP that wish to submit data under the required standardized methodology.

Objective 7: Database Publication on the World Wide Web

Tasks. Provide immediate, minimal cost, worldwide access to the Database by establishing an Internet site for the Database and publishing its data on the World Wide Web.

Accomplishments. The Database currently resides on a Windows-NT server and is maintained using relational database software (Access, Microsoft). A server application (Cold Fusion, Allaire) is used to support client-server database access and database publication via the Internet (World Wide Web). A number of Web forms have been developed to support tabular data retrieval. A programming language (Java, Sun Microsystems) is used to embed time-series and water-depth based plots in Web pages for graphical data retrieval. Further discussion of computer software technology required to support the Database Web Site may be found in the Database Proposal (Eighth Work Plan). Location of the Database on an OSU College of Engineering Network Server, at the Bioresource Engineering Deptartment, provides permanent housing of the Database, centralized, secured storage with automated backup procedures, and Internet accessibility. Internet accessibility to the Database via the World Wide Web is available at http://www.biosys.orst.edu/crspdb.

Data may be searched, extracted, reviewed, and/or downloaded according to user-specified geographical location, inclusive calendar years, fish species and stocks, and fish production methods. In this respect, the experimental treatment protocols by which the research was accomplished correspond to equivalent fish-culture management scenarios that can be considered by data users. Data available from the Database include 1) site weather, 2) pond/site soil composition, 3) pond mapping and water management, 4) pond application materials, rates, and compositions, 5) fish numbers, weights, and lengths at stocking, during culture period, and at harvest, 6) water quality variables, and 7) natural biological-productivity variables.

To be completed. Data currently available at the Database Web Site are raw, replicate sampling data in tabular format only (e.g. water temperature and fish weight time-series data). Under development is presentation of data in graphical formats and in a variety of additional forms, including 1) calculated data (e.g., fish biomass productivity and feed conversion efficiency), 2) statistical summaries (e.g., treatment means, variances, and analysis of variance), and 3) fitted model parameters (e.g. fish growth and water quality models). In this respect, experimental treatments may be viewed and analyzed as individual entities, grouped according to their original experiments, or recombined to create new experiments.

Also to be completed is to provide data-users with additional experiment information specific to an extracted dataset, including research personnel citations (analogous to printed publications), physical descriptions of research facilities, and references to related publications (see Objective 8).

Objective 8: Linkage with the Program Management Office Web Site

Tasks. Provide direct, context-sensitive linkage between the Database and the Program Management Office Web Sites. Support Database access to research site descriptions, research personnel citation information, publication references, and publication texts.

Accomplishments. A need for Database linkage to additional PD/A CRSP information was recognized in order to provide necessary contextual support for specific, extracted datasets. This information includes:

- Principal investigators responsible for specific experimental datasets, to support data citations and referrals, analogous to printed publications.
- Site and facility descriptions and physical data, to be used in conjunction with experiment-treatment specifications.
- References to PD/A CRSP literature (Workplans, Technical Reports, Annual Reports, etc.) and other external publications, to be used to augment experiment treatment descriptions, provide research objectives and context, and provide experimental results and discussions.

Discussions with the Program Management Office have shown that they already maintain information on research personnel, research facility descriptions, and research publications (references and texts). Thus, this information will continue to be maintained by the Program Management Office, while actual housing of this information at the Database or Program Management Office Web Sites is under discussion. Context-sensitive linkage will be supported by simply using the specific location (research site) and time (calendar years) of an extracted dataset.

To be completed. Further discussion with the Program Management Office is required to determine data housing locations, specific mechanisms of data linkage and access, and division of responsibilities between the Program Management Office and the Database Manager. An overall plan that is emerging is to use the Database to house all elemental data (numbers and text strings) including facility specifications, publication references, and personnel information. The Program Management Office Web Site would be used to house complete document texts. As done historically, the Program Management Office will be responsible for maintaining personnel, facility, and publication information.

Objective 9: Database Promotion

Tasks. Enhance awareness of the Database in the greater aquaculture community and create additional opportunities for its use. Make the Database available through other public databases. Actively promote its use through aquaculture conferences and publications.

Accomplishments

- Database Web Site Publication. As presented above, publication of the Database on the World Wide Web will greatly enhance its visibility and availability to the aquaculture community worldwide.

- International Symposium on Tilapia in Aquaculture (ISTA IV). A paper entitled "PD/A CRSP Central Database: A Standardized Information Resource for Pond Aquaculture" (Douglas H. Ernst, John P. Bolte, Duncan Lowes, and Shree S. Nath) has been prepared for ISTA IV, for presentation at its upcoming meeting (Nov. 1997, Orlando, FL) and publication in its proceedings.

- AquaNIC. A link to the Database Web Site is provided at AquaNIC, an Internet-based aquacultural information service maintained at Purdue University.

- Oregon Department of Fish and Wildlife (ODFW). A seminar by Doug Ernst and John Bolte was given to ten people from the ODFW (May 23, 1997), with one component addressing procedures and methods of the Database and its Web Site interface. Applications similar to the Database for use in ODFW salmon hatchery management were discussed. The relationship of the ODFW Central Office to its multiple hatchery sites and needs for standardized data storage and access are similar to the data publication needs and relationship of the Program Management Office and its multiple research sites.

To be completed

- ICLARM FishBase. Summary data compiled from the Database will be included in FishBase (Froese and Pauly, 1996), starting with FishBase 1998. FishBase provides a wealth of fish biology, fish taxonomy, fisheries, and aquaculture information compiled from a wide range of sources.

- Consortium of International Earth Science Information Networks (CIESIN). To consider fish production information available in the Database in conjunction with additional, geographical information available for a given research site, data from the Database may be used in conjunction with geographical data from other sources. One approach to this task, that will be available by Dec. 1997, is to access summary data compiled from the Database via CIESIN. CIESIN maintains a worldwide, geographically based, environmental information database that is publicly available at the CIESIN Web Site (access via the Database Web Site).

- World Aquaculture Society (WAS). A technical session entitled "Use of Computer Tools for Aquaculture Planning, Design, and Management" is being organized for the next WAS annual meeting (1998, Las Vegas, NV) by Shree Nath and Doug Ernst. Use of standardized aquaculture research methods and databases for computer tool development, as represented by PD/A CRSP research and Database, respectively, will be an important component of this session.

Literature Cited

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Egna, H.S., Brown, N., and Leslie, M. (Eds.), 1987. Pond Dynamics/Aquaculture Collaborative Research Data Reports, Vol. 1: General Reference. Pond Dynamics/Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, OR USA. 84 pp.

Ernst, D.H., 1997. Pond Dynamics/Aquaculture Collaborative Research Database Manual. Pond Dynamics/Aquaculture Collaborative Research Support Program, Oregon State University, Corvallis, OR USA. 30 pp.

Froese, R., and Pauly, D. (Eds.), 1996. FishBase 96: Concepts, Design, and Data Sources. ICLARM, Manila, Philippines. 179 pp.

Piedrahita, R.H., Boyd C., and Szyper, J., 1991. Handbook of Analytical Methods. Pond Dynamics/Aquaculture Collaborative Research Support Program, OSU, Corvallis, OR USA. 150 pp.

4.3 Information Management

The Information Management and Networking Component (IMNC), the research support component that works most closely with the Program Management Office (PMO), performs critical organizational roles related to information. IMNC is charged not only with the dissemination of technical and programmatic information, but also with the collection and analysis of impact information. This component also facilitates electronic and face-to-face networking. IMNC works in very close collaboration with the PMO. This chapter focuses on the activities of the IMNC itself. Networking activities of the program, as reported to by program researchers to the IMNC, are presented in Chapter 4.4.

Since this first year of the *Continuation Plan 1996-2001* was also the first year of the IMNC component, project staff last fall participated in an iterative process to develop a component mission statement and strategic plan. Those meetings yielded a detailed annual calendar of publications and other milestones aimed to focus staff resources and to meet reporting deadlines imposed by the terms of the program grant as well as by the CRSPs own priorities and objectives. The IMNC mission statement is:

> To increase awareness and visibility of the PD/A CRSP by publishing and providing accessible technical and programmatic information, to monitor and report CRSP impact, and to foster networking among persons involved in aquaculture.

Objectives are to:

- Identify target audiences for publications;
- Disseminate technical and programmatic information generated by the CRSP by providing appropriate materials and avenues;
- Track outputs of CRSP investigations;
- Promote networking of CRSP participants with aquaculturists around the world.

During the reporting year, IMNC staff conducted a thorough overhaul of the program's mailing list database, which now numbers over 850 entries from 56 countries. After establishing a set of name and address conventions, each entry was individually reviewed and brought up to the standard. Next, staff developed a brief survey questionnaire whose purpose included: 1) to determine what type of readership received program mailings (some options were student, researcher, and producer); 2) to confirm that readers continued to be interested in receiving program information; 3) to verify name and address information; 4) to inform readers that most program information, including *Aquanews*, was available in electronic format via the program World Wide Web site.

With the July distribution of the Summer issue of the program newsletter, *Aquanews*, readers also received the survey. The high ratio of mailings to responses suggests that responses are not representative of the group. The overwhelming majority of respondents indicated that they were researchers who wished to continue to receive program publications. Whether researchers who like *Aquanews* are more likely to respond to questionnaires than are other types of readers who do not is a likely confounding variable.

In addition to maintaining a detailed inventory of PD/A CRSP publications, IMNC staff also began tracking publication circulation and distribution during this reporting period in an effort to better gauge what areas of research are of highest interest to the constituency who requests program materials. Since this tracking system is new, no significant trends are yet apparent.

World Wide Web

In 1995 the CRSP IMNC brought a WWW homepage on-line. Internet users linking to this site have access to information relating to study sites, software, and publications (available in both html and Acrobat formats). Users are also able to place publication orders or other requests for information directly to an electronic mail account at OSU. The site, located at http://www.orst.edu/dept/crsp/homepage.html, also contains numerous options for linking to other existing aquaculture sites on the Internet.

Enhancements to the information content of the web site during the reporting period include new pages relating to research site descriptions and a new directory of PD/A CRSP Principal Investigators. Technological improvements include: installation of visitation tracking devices on major pages of the PD/A CRSP web site; development of a more user friendly, online publications order form; and web site redesign to cater better to the broad range of computer hardware and browser types and enhance search engine access. There was also close collaboration with PD/A CRSP Central Database project staff on the design of a web-based, searchable publications database and on the integration of web-based publications, site-information and experimental data. Access to program documents and other information by CRSP researchers at all sites expedites and facilitates discussion of information and cohesion among participants that are geographically disperse.

CRSP Publications

A 10-year bibliography of CRSP researcher publications appears in Appendix B.

This reporting period saw the actual finished product of the new multi-authored book entitled, “Dynamics of Pond Aquaculture,” published by CRC Press/Lewis Publishers. This new collection, which approaches aquaculture production as part of the larger agroecosystem, was edited by CRSP Director Hillary Egna and CRSP Principal Investigator Claude Boyd. Director Egna also wrote two of the book’s 16 chapters. A great number of CRSP researchers were chapter contributors to this effort. Individual author and chapter citations appear in Chapter 4.4 in “CRSP Contributions to Scholarly Publishing.”

During the reporting period, IMNC assisted with the production and distribution of the publications noted below.

PD/A CRSP USAID Grant Document, 1 August 1996 through 31 July 2001.

CRSP Working Paper on Regional Plans. July 1997. 26 pp.

PD/A CRSP Data Report, v. 1, General Reference: Site Descriptions, 2nd. ed.
Bowman, J. ed. 1996. Pond Dynamics/Aquaculture Collaborative Research Support Program. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 74 pp.

Fourteenth Annual Administrative Report
Clair, D., B. Goetze, D. Burke, M. McNamara, and H. Egna, eds. 1996. Pond Dynamics/Aquaculture Collaborative Research Support Program. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 94 pp.

Fourteenth Annual Technical Report
Burke, D., B. Goetze, D. Clair, Egna, H., eds. 1996. Pond Dynamics/Aquaculture Collaborative Research Support Program. Office of International Research and Development, Oregon State University, Corvallis, Oregon. 192 pp.

Eighth Work Plan
This document describes the standardized set of experiments to be undertaken by the CRSP during the period 1 August 1996 through 31 July 1998. Printed Summer 1997, 172pp.

CRSP Participant Directory, published December 1996 and July 1997.

CRSP List of Publications and Order Form, published December 1996 and July 1997.

CRSP Research Reports
This is an in-house publication series which includes Notices of Publication. The following Research Reports were issued in the last year:

96-97 Effect of stocking ratio on semi-intensive polyculture of *Colossoma macropumum* and *Oreochromis niloticus* in Honduras, Central America. (11/96)
96-98 Texture and chemical composition of soils from shrimp ponds near Choluteca, Honduras. (11/96)
97-99 Institutional requirements for aquacultural development in Africa: Lessons from Rwanda. (1/97)
97-100 Estimating *Oreochromis nilotica* production function for small-scale fish culture in Rwanda. (1/97)
97-101 Phosphorus fertilization strategy in fish ponds based on sediment phosphorus saturation level. (1/97)
97-102 Polyculture of tilapia with marine shrimp. (1/97)
97-103 Timing of supplemental feeding for tilapia production. (4/97)
97-104 Optimal resource allocation by fish farmers in Rwanda. (4/97)
97-105 Observations and model predictions of daily areal primary production in a eutrophic brackish water culture pond. (4/97)

97-106 Comparison of three mixing devices in earthen culture ponds of four different surface areas. (4/97)
97-107 Inclusion of tilapia as a diversification strategy for penaied shrimp culture. (5/97)
97-108 Semi-intensive shrimp pond management and quality of effluents. (5/97)
97-109 The Pond Dynamics/Aquaculture CRSP-sponsored proceedings of the third conference on the culture of tilapias at high elevations in Africa. (6/97)
97-110 The CRSPs: International collaborative research support programs. (6/97)

Impact Monitoring

During year one of the *Continuation Plan 1996-2001*, impact indicators for project monitoring were developed for each project activity. These were jointly developed by IMNC staff and researchers. These indicators are listed in each subcontract and were arrived at in discussions between researchers and IMNC.

Starting in July of this year, a review of impact indicators was conducted to determine whether they adequately reflect and record project impact. An advisor to the IMNC project with expertise in project monitoring has been working with researchers directly to help them identify and formulate indicators for their project sub-contracts that measure impact (rather than output). In cases where baseline data is not available, there may be a need to expand the scope of data collection or make changes. Several researchers have already made changes to their indicators and are in the process of having these accepted through the PMO. This process is still on-going. The end result is that the program will have a much better framework for determining project impact.

In addition to these formal impact indicators, IMNC staff developed an impact form which is designed to capture researcher activities related to items such as:

- Institution building (contacts with host country scientists, government officials, extension, agents, farmer organizations, farmers, non-governmental organizations)
- New host country involvement
- Physical support for host country institutions (i.e., pond renovation)
- Linkage development (with USAID missions, regional institutions, etc.)
- Conferences attended
- Seminars, presentations, and or workshops given
- Electronic linkages
- Publications
- Theses
- Informational material developed

These forms are requested on a quarterly basis and allow the IMNC to monitor and track progress in the areas of outreach, public service and professional development.
Chapter 10 provides an encapsulation of information contained in impact reports submitted by researchers during this reporting period.

Program Promotion

IMNC also develops displays for use at aquaculture and other, more general, academic conferences and exhibits. One example of this is an annual event at Oregon State University called University Days. This event is an opportunity for new faculty to become acquainted with campus programs. The CRSP takes advantage of University Days to showcase the program and to inform new potential collaborators about program activities on campus, throughout the US, and abroad.

4.4 Networking

Developing and maintaining links among collaborating universities and government ministries, departments of agriculture, and private sector aquaculturists around the world forms a significant ancillary contribution to the CRSPs research effort and to the goal of expanding the role of aquaculture in the developing world. This chapter describes linkages and connections made not only by CRSP researchers in the field and reported to the Program Management Office during this reporting period, but also those maintained by the Program Management Office. CRSP participation in scientific meetings and conferences, and contributions to scholarly publishing are also described.

Field Linkages

Honduras Project

The CRSP in Honduras continues its close association with the major aquaculture groups active in the area—ANDAH and EAP (Asociacion Nacional de Acuicultores de Honduras or the National Association of Honduran Aquaculturists and Escuela Agricola Panamericana or Panamerican Agriculture School, respectively). CRSP researchers are also exploring a renewed collaborative relationship with FPX, the Honduran Federation of Agricultural and Agroindustrial Producers and Exporters. In addition, researchers have established connections with people involved in other projects and programs operating in the region, among them the World Wildlife Fund, Programa Ambiental Regional para Centroamerica (PROARCA), the USAID mission, and various government offices with interests in fisheries and the environment.

In an effort to provide greater access to timely and relevant technical material, Honduras Project Principal Investigator Bart Green coordinated the establishment of an aquaculture library at the EAP in Zamorano, Honduras. Faculty from Auburn University's Fisheries and Allied Aquacultures Department donated 66 aquaculture and fisheries books, 78 aquaculture and fisheries periodicals, and several hundred off-prints of scientific papers to the library.

CRSP researchers in Honduras have also been actively engaged in technology transfer, discussing, for example, strategies to improve fingerling production with Honduran CRSP alumni who are now active in private sector aquaculture.

University of Texas researchers have been working on developing electronic linkages with the Center for Export and Investment in Nicaragua regarding tilapia and shrimp collaborative activities and with PRADEPESCA (Regional Program for Fisheries Development Support in the Central American Isthmus), a European Union-funded project on fisheries and aquaculture active in Central America.

Faculty from the University of Arkansas at Pine Bluff who are involved in aquaculture marketing and economic analysis research have discussed a proposed CRSP survey with officials at ANDAH and with the private sector involved in the Honduran shrimp farming industry, including FPX, to engender support for this research effort.

Peru Project

Peru project researchers met with scientists and administrators of the National University of the Peruvian Amazon and the Institute for the Investigation of the Peruvian Amazon in November 1996 to formally establish the linkage agreements and to make plans for the CRSP project. The Memorandum of Understanding among these two institutions and Southern Illinois University, Carbondale, was executed in November 1996. CRSP researchers in Peru have also been looking into potential formal collaboration with the Aquaculture Centre of the National University of Sao Paulo, Brazil.

Kenya Project

Oregon State University and Auburn researchers involved in the Kenya project have been active in developing connections with individuals in government, academe, and non-governmental organizations throughout East Africa. The MOU between Oregon State University's Department of Fisheries and Wildlife and the Department of Fisheries under the Kenya Ministry of Tourism and Wildlife was authorized in March 1997.

Mathias Wafula (left) and current Head-of-Station Bethuel Omolo (second left) discuss ideas for Work Plan proposals with Provincial Fisheries Officers during a CRSP-sponsored workshop held at Sagana Fish Farm in September 1997.

Other groups with whom Kenya project staff have been in contact include:

- Aquaculture for Local Community Development Programme (ALCOM), Harare, Zimbabwe;
- ALCOM Tanzania;
- Regional Cooperation in Scientific Information Exchange—Western Indian Ocean (RECOSCIX), a program involved in the dissemination and management of information in the marine sciences, serving marine science research units all over East Africa;

- Peace Corps Congo;
- Fisheries Research Institute, Uganda;
- Department of Fisheries and Watershed Management, Institute of Renewable Natural Resources, University of Science and Technology, Ghana; and
- InterCRSP Natural Resources Management Project in Cape Verde, The Gambia, Mali, and Senegal.

Within Kenya, CRSP researchers have met with representatives of the Kenya Marine Fisheries Research Institute (KMFRI) and of the Kenya Fisheries Department. CRSP work plan activities have been shared with these groups, and CRSP researchers have put forward graduate thesis subjects for university students. Possible ways in which KMFRI and the Fisheries Department can collaborate with the CRSP have also been discussed.

Locally, the PD/A CRSP is seen as a source for information and recommendations on semi-intensive aquaculture in the area. Kenya project staff have met with fisheries officers from the Nairobi and Embri districts to discuss fish culture activities and problems in these districts. The CRSP may be able to assist by providing recommendations for ponds in higher elevations, thus borrowing from its work in Rwanda.

Private sector involvement by Kenyan project staff includes contacts with several prospective tilapia farmers in Kenya and Rwanda.

During a visit to the Sagana Station, the University of Arkansas at Pine Bluff researcher involved in the Kenya project met with project staff, University of Nairobi graduate students who may become involved with CRSP activities as part of their graduate studies, and fisheries policy makers.

Thailand Project

University of Michigan researchers involved with the Thailand project have also been active in seeking out connections with representatives of local and regional governments, non-governmental organizations, and private industry.

During the reporting period, researchers met with the Director General of Livestock, Fisheries, and Veterinary Science of Laos People's Democratic Republic to discuss the potential for CRSP collaborative work in that country. A follow-up visit is planned for next year. CRSP researchers also attended a workshop entitled "Establishment of a national aquatic resources management institute" sponsored by the Mekong River Commission. Other participating organizations included the Food and Agriculture Organization of the United Nations (FAO), the International Development Research Center (IDRC), the Japan International Cooperation Agency (JICA), and others.

CRSP researchers also collaborated with staff of an FAO/Belgium project based in Cambodia on a problem related to cage culture and water quality on the Tongle Sap River.

Collaboration with Vietnamese aquaculture counterparts is progressing by means of a CRSP visit to Research Institute for Aquaculture No. 3 in Nhatrang and meetings with provincial fisheries officers in Minhai on the Mekong delta. In addition, the Asian Institute of Technology (AIT) has a collaborative relationship with Research Institute for Aquaculture No. 1 in North Vietnam, whereby two AIT doctoral students have been conducting thesis research on development of tilapia culture in North Vietnam.

Within Thailand, CRSP scientists maintained strong connections with government fisheries stations and fish farmers throughout the country, making visits to stations and farms in Udorn, Sakhon Nakhon, Kalasin, Roi Et, and Khonkhen Provinces. Researchers also assisted a local charity organization in Chiang Rai by providing advice on backyard catfish-tilapia integrated culture.

Contact was also established with the Udorn Development Foundation in Thailand, whose work focuses on integrated upland agriculture and aquaculture.

Auburn University social scientists have been in direct contact with ICLARM, engaging in a publication exchange. Auburn University social scientists assisted ICLARM by commenting on an evaluation strategy and design, and they have also been in contact with researchers at Cantho University in Vietnam.

Linkages Reported by Cross-cutting Projects

Data Analysis and Synthesis Team (DAST) researchers at OSU have worked collaboratively with staff of FAO. The final report of work on a Global Information System (GIS) for assessment of fish farming potential in Latin America has been completed. Continuing collaboration will involve a GIS to assess aquaculture potential in Africa. As of the time of this writing, water temperature projections had been made for the Africa GIS project, and the POND© bioenergetic models were in the process of being refined for use in predicting fish performance for pond systems in Africa.

Other collaborative work by DAST members included organizing a visit to OSU by a faculty member of the Department of Fish Culture and Fisheries, Wageningen University, The Netherlands. During that visit OSU CRSP participants attended a seminar on the research activities of the work being conducted in The Netherlands and discussed future areas of collaboration between Wageningen University and the CRSP.

At the University of Davis, California, a doctoral student has been assisted in his work on modeling integrated agriculture and aquaculture systems by a connection with ICLARM in Malawi. The student has used data collected by ICLARM in Malawi on aquaculture and agriculture experiments. The data complements PD/A CRSP data.

Dr. Claude E. Boyd met with representatives of NACA, the Network of Aquaculture Centers in Asia Pacific, in Bangkok to discuss possible collaboration on environmental issues in aquaculture. A similar discussion is also underway with the director of the Ministry of

Fisheries for the Loreto Region, where CRSP activity is taking place. In addition, researchers from the Royal Thai Government Department of Fisheries collaborate with CRSP researchers on work related to soil sampling in Thailand.

During the year C. E. Boyd made use of CRSP data in his service as a private sector consultant to numerous enterprises and organizations involved in shrimp farming in Ecuador, Tanzania, Thailand, Malaysia, Indonesia, and West Australia.

Program Management Office Linkages

In addition to the linkages developed by researchers, the Program Management Office also maintains ties with numerous other organizations, including some commercial fish producers in the U.S. and in host countries. A partial list of these CRSP linkages follows:

American Association for the Advancement of Science (AAAS)
American Fisheries Society
American Tilapia Association, United States
Association for International Agriculture and Rural Development (AIARD)
Bean/Cowpea CRSP
Board for International Food and Agricultural Development (BIFAD) Washington, D.C.
Cairo University, Egypt
Catholic University of Leuven (CUL), Belgium, Rwanda
Consortium for International Earth Science Information Network (CIESIN), Washington, D.C.
Consultative Group on International Agricultural Research (CGIAR), Washington, D.C.
CRSP Steering Council
Department of Fisheries, Udorn Thani, Thailand
Escuela Agrícola Panamericana (EAP), Honduras
European Economic Community
European Inland Fisheries Advisory Commission (EIFAC)
Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
Aquaculture for Local Community Development Programme (ALCOM)
Inland Water Resources and Aquaculture Service
Institut Pertanian Bogor (IPB), Indonesia
Integrated Pest Management CRSP
International Center for Aquaculture (ICA), Auburn University, Alabama
International Center for Living Aquatic Resources Management (ICLARM), Philippines
International Development Bank (IDB)
International Development Research Centre (IDRC) of Canada
International Sorghum and Millet (INTSORMIL) CRSP
National Agricultural Library, Washington, D.C.
National Inland Fisheries Institute (NIFI), Thailand
National Technical Information Services, (NTIS) Springfield, Virginia
Network of Aquaculture Centers in Asia Pacific (NACA)
North Central Regional Aquaculture Center (NCRAC), Michigan
Peanut CRSP

Post Harvest CASP
Small Ruminant CRSP
Soil Management CRSP, Honduras
South East Asian Fisheries Development (SEAFDEC), Philippines
Southern African Development Community (SADC)
Special Program for African Agricultural Research (SPAAR), Washington, D.C.
Sustainable Agriculture and Natural Resources Management (SANREM) CRSP
The University of the Philippines in the Visayas
United States Department of Agriculture (USDA), Washington, D.C.
United States Fish and Wildlife Service, Washington, D.C.
University of Washington, Seattle, Washington
Western Regional Aquaculture Consortium (WRAC), Seattle, Washington
World Aquaculture Society (WAS), Baton Rouge, Louisiana

Participation in Scientific Meetings and Conferences

CRSP researchers contribute to the general aquaculture community through their participation in scientific meetings and conferences in the United States and abroad. During this reporting period, CRSP researchers participated in the following activities.

Kwei Lin attended annual meeting of Network of Aquaculture Centers in Asia-Pacific (NACA) in Bangkok, Thailand. Participants included 12 representatives from member countries and international organizations. He also took part in a workshop on "Danish-Southeast Asian collaboration in tropical coastal ecosystems research and training" in Bangkok, sponsored by the Danish Cooperation for Environment and Development (DANCED), a technical cooperation program between the Government of Malaysia and the Government of the Kingdom of Denmark.

In September 1996 Claude Boyd presented "Recent advances in aeration technology" at the INFOFISH conference held in Kuala Lumpur, Malaysia.

Jim Diana delivered a presentation on "Consequences of cage culture in reservoirs—case study of Cirata Reservoir, Indonesia" in Vientiane, Laos, at a Mekong River Commission workshop in March 1997.

At the National Aquaculture Extension Conference held 9-10 April 1997 in Annapolis, Maryland, Shree Nath conducted a demonstration of the POND© and AquaFarm software developed by John Bolte, Doug Ernst and Nath at the Department of Bioresource Engineering, Oregon State University. He also presented "Planning, design, and management tools for aquaculture" at the conference poster presentation.

In April 1997 Claude Boyd spoke before the Global Aquaculture Alliance in Tegucigalpa, Honduras on "Examples of best management practices (BMPs) for shrimp farming."

Bart Green was a member of the Organizing Committee of the IV Central American Symposium on Aquaculture that took place in Tegucigalpa, 22-24 April. The meeting was co-sponsored by the ANDAH (National Association of Honduran Aquaculture) and the Latin American chapter of World Aquaculture Society. Green worked closely with ANDAH personnel and members of the Organizing Committee. Green served as a co-editor for the Symposium Proceedings. In addition to Green, David Teichert-Coddington and Claude Boyd attended the symposium and were presenters.

Thailand project Co-Principal Investigators Jim Diana and Kwei Lin.

In June 1997 C.K. Lin led a seminar for Thai fisheries officers on "Trends of future development and water uses in freshwater aquaculture in Thailand" at the invitation of the Royal Thai Department of Fisheries.

Lin also spoke in July at an IFREMER meeting about coastal environmental management for sustainable aquaculture in Jakarta, Indonesia, on sludge production and management for intensive shrimp culture ponds. While in Jakarta, Lin spoke on opportunities and challenges for aquaculture in the ASEAN region before members of the International Agribusiness Management Association.

The following papers were presented at the 1997 Annual Meeting of the World Aquaculture Society in Seattle, Washington, by CRSP researchers:

Bolte, J. and S. Nath. POND©: A decision tool for warmwater aquaculture.
Boyd, C.E. Environmental issues in aquaculture.
Boyd, C.E. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand.

Ernst, D.H., J.P. Bolte, and S.S. Nath. Application of decision support software for aquaculture facility design.

Fitzpatrick, M.S., W.L.Gale, W. Contreras, and C.B. Schreck. Masculinization of Nile tilapia (*Oreochromis niloticus*) by short-term immersion in methyldihydrotestosterone.

Green, B.W., D.R. Teichert-Coddington, G.H. Ward, and C.E. Boyd. Collaborative research to support sustainable shrimp culture in Honduras: A model program.

Jamu, D.M. and R.H. Piedrahita. A nitrogen and organic matter cycling model for an integrated aquaculture-crop system.

Kapetsky, J.M., S. Nath, and J.P. Bolte. A fish farming GIS for Latin America

Lu, Z. and R.H. Piedrahita. Modeling of temperature and dissolved oxygen in stratified aquaculture ponds using stochastic weather variables.

Molnar, J., T. Hanson, and L. Lovshin. Doing science, growing fish, teaching people: Human capital impacts of the pond dynamics aquaculture CRSP.

Nath, S., J.P. Bolte, and D.H. Ernst. A fish bioenergetics model for pond aquaculture

Yi, Y. and C.K. Lin. An integrated rotation culture system for fattening large Nile tilapia in cages and nursing small Nile tilapia in open ponds.

Shree Nath and Doug Ernst, Department of Bioresource Engineering, Oregon State University have done preparatory work for their session entitled, "Computer Tools for Siting, Designing and Managing Aquaculture Facilities," at the 1998 WAS meeting in Las Vegas, Nevada. The session will be co-sponsored by the Bioengineering Section of the American Fisheries Society and the Aquacultural Engineering Society. The session will feature 15 and 30 minute presentations from invited speakers and will cover regional- and facility-scale tools developed for aquaculture. A special issue of the Aquacultural Engineering journal will also be devoted to the topic.

CRSP Contribution to Scholarly Publishing

CRSP researchers are significant contributors to scholarly literature in the fields of aquaculture and sustainable development. The following represents the published work of CRSP participants during the reporting period.

Boyd, C.E. and J.R. Bowman, 1997. Pond bottom soils. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press LLC, Boca Raton, pp. 135-162.

Boyd, C.E. and P. Munsiri, 1997. Water quality in laboratory soil-water microcosms with soils from different areas of Thailand. Journal of the World Aquaculture Society, 28(2):165-170.

Contreras-Sánchez, W.M., M.S. Fitzpatrick, R.H. Milston, and C.B Schreck, 1997. Masculinization of Nile Tilapia (*Oreochromis niloticus*) by single immersion in 17α-methyldihydrotestosterone and trenbolone acetate. Fourth International Symposium on Tilapia in Aquaculture. (Accepted.)

Diana, J.S, 1997. Feeding strategies. In: H. Egna and C. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press LLC, Boca Raton, pp. 245-262.

Diana, J.S., C.K. Lin, and Y. Yi, 1996. Timing of supplemental feeding for tilapia production. Journal of the World Aquaculture Society, 27:410-419.

Egna, H.S., 1997. History of the Pond Dynamics/Aquaculture Collaborative Research Support Program. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press LLC, Boca Raton, pp. 19-52.

Egna, H.S., C.E. Boyd, and D.A. Burke. 1997. Introduction. In: H.S. Egna and C.E. Boyd (Editors), Dynamics of Pond Aquaculture. CRC Press LLC, Boca Raton, pp. 1-18.

Engle, C.R., 1997. Optimal resource allocation by fish farmers in Rwanda. Journal of Applied Aquaculture, 7(1):1-17.

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5. Program and Technical Guidance

The PD/A CRSP is administered by Oregon State University, which functions as Management Entity (ME) and has technical, programmatic, and fiscal responsibility for the performance of the USAID grant provisions. The ME appoints a Program Director to administer the CRSP. Program functions are carried out through a Program Management Office (PMO), which is the operational component of the ME and serves as the link between USAID and the CRSP projects. The PMO is supported by three advisory bodies: the Board of Directors (BOD), the Technical Committee (TC), and the External Evaluation Panel (EEP). Program participants, including PMO staff and BOD, TC, and EEP members, are identified in Chapter 14, Staff Summary.

PMO Activities

Major highlights of 1996-1997 Program Management Office activities include:

- Commencement of *Continuation Plan 1996-2001* activities under the PD/A CRSPs new five-year USAID grant. Subcontracts were issued to research projects at the following US institutions:

  Auburn University (5)
  Southern Illinois University at Carbondale (1)
  The University of Michigan (1)
  University of Arizona (1)
  University of Arkansas at Pine Bluff (2)
  University of California at Davis (1)
  University of Oklahoma (1)
  University of Texas (1)

In addition, the PMO, which is itself housed in the Office of International Research and Development at Oregon State University, issued intramural Memoranda of Understanding to projects based in the Departments of Fisheries and Wildlife (2) and Bioresource Engineering (2).

- Development of impact indicators to measure project success and relevance
- Development of Regional Plan concept for increasing impact of research accomplishments
- Development of Philippines project Request for Proposals and conduct of peer reviews
- Completion of Eighth Work Plan
- Initiation of Ninth Work Plan Request for Proposals
- Search and appointment of three new members of the Board of Directors
- Successful nomination of new External Evaluation Panel member
- Recruitment and hiring of program financial manager
- Coordination of the 14th Annual Meeting, 17-19 February 1997, in Seattle, Washington
- Participation in West Africa Natural Resource Management InterCRSP planning activities
- Participation in USAID revision of the participant training guidelines (Handbook 10, Chapter 253)

- Contribution to USAID publication on CRSPs entitled, "Global Research for Sustainable Development,"
- Editing and writing of "Dynamics of Pond Aquaculture," a multi-author text on the latest advances in aquaculture
- Commissioning of a handbook on fertilization guidelines
- Assisting with the development of new Memoranda of Understanding between US and Host Country institutions

CRSP publication and information-related work of the program management office is carried out by the program's Information Management and Networking research support component and is described in Chapters 4.3 and 4.4.

Meetings

In September 1996, Deputy Director Brigitte Goetze attended the INTSORMIL Principal Investigators Conference in Lubbock, Texas, as an observer. The information gleaned was useful in establishing the PD/A CRSPs regional plan development process. In October, Director Egna participated in International Centers Week and met with representatives of ICLARM (International Center for Living Aquatic Resources Management) in Washington DC; in December, she traveled to Chicago to attend meetings of the InterCRSP and of the CRSP Council; in January, the Director went to Washington to participate in a meeting of CRSPs, IARCs (International Agriculture Resources Centers), and universities with Board Chair Bryan Duncan; during an April visit to Washington, the Director met with USAID technical and contract staff, with representatives of CIESIN (Consortium for International Earth Sciences Information Network), and with External Evaluation Panel member Gary Jensen; in June she traveled to Washington to attend a meeting of AIARD (Association for International Agriculture and Rural Development) and to meet with USAID staff.

At the 1997 meeting of the World Aquaculture Society in Seattle, Washington, Director Egna spoke on the history and experience of US institutions of higher learning working with USAID in a talk entitled, "International Aquaculture: Research."

Director Egna also participated in CRSP Council conference calls on 3 October 1996, 7 November 1996, 6 February 1997, 21 March 1997, and 29 May 1997. Among other collaborative activities during the reporting period, the CRSP Council prepared and submitted to USAID a set of recommendations for revised BIFAD guidelines relating to CRSPs.

Advisory Groups

Three advisory groups–the Board of Directors, Technical Committee, and External Evaluation Panel–support the management of the CRSP. These groups work closely with the Director to assist the ME with policy decisions, budget allocations, research strategy, review, and evaluation.

Board of Directors

The Board consists of a minimum of four representatives from participating institutions and operates under a defined charter to deal with policy issues, to review and approve plans and proposed budgets, to assess progress, and to advise the PMO on these and other matters. The Project Officer from USAID and the CRSP Director serve as ex-officio Board members.

The ME has a permanent member on the Board (this member is not eligible to serve as chair). The three other Board members come from participating US institutions on a rotating basis. Outside members may be appointed to the Board based on availability of funding and need. Board members are selected by their participating institutions from their higher administrative management levels. Selections are based on their responsibilities and relevant experience. The term length on the Board is three years, typically with service as chair in the third year.

CRSP researchers Raul Piedrahita and Antonio Circa chat with Mark Prein of ICLARM during the program's 1997 Annual Meeting in Seattle, Washington.

BOD members came together at the PD/A CRSP Annual Meeting (17-19 February in Seattle, Washington), where two Board meetings were held, one on general program activities and one specifically devoted to policy setting. In June the Board participated in a mail ballot vote on a budget allocation issue at the request of the Director. During the year the BOD also provided input on the Ninth Work Plan Request for Proposals, Regional Plan development and other issues. The director holds informal discussions regularly with the Board, and advice on some decisions is provided through correspondence.

Technical Committee

Technical guidance for the program is provided by the Technical Committee (TC), whose purpose is to monitor the technical research of the PD/A CRSP, propose modifications, and recommend allocations of funds for research activities. The USAID Project Officer, CRSP Director, and Deputy Director serve as ex-officio members on the TC.

Under the *Continuation Plan 1996-2001* the structure of the TC was modified as a way to ensure equitable representation of participating institutions and to encourage diversity of expertise in the program's three strategic research areas: production optimization, environmental effects, and social and economic aspects (see Chapter 3). TC members are selected based on their expertise in these areas and once selected represent their respective disciplines; at least three TC members represent each of the three strategic research areas. Host country members are included in the selection process. In addition, the PMO may appoint additional members to the TC to provide expertise in unrepresented areas. TC members serve for three-year terms. Each member, with the exception of the Chair or Co-Chairs, serves as an active member of one of three standing subcommittees: Work Plan and Budget, Technical Progress, or Materials and Methods.

In the fall of 1996 program principal investigators participated in an election process to implement the new TC structure described above. (See Chapter 14, Staff Summary, for the composition of the new TC.) The newly-elected TC met for two days at the February 1997 Annual Meeting in Seattle. Major items under consideration in Seattle were follow-up on the election, fine-tuning of committee bylaws, technical components of the Philippines Request for Proposal, and the development of Regional Plans. Also during the Annual Meeting, the TC conducted the election for an at-large TC member.

External Evaluation Panel

The External Evaluation Panel (EEP) periodically evaluates the accomplishments of CRSP research activities and of the program as a whole. The EEP reviews the CRSP annually and provides an in depth review every five years. EEP reviews are of great use to the ME for program management purposes. Once received, the ME shares EEP reviews with the program's advisory bodies and with USAID. At that time the ME also has an opportunity to address points made in the review. ME responses to the EEP review are included as part of the final EEP Report that is produced for general distribution.

The panel is composed of up to four specialists who are external to the program. Members are selected so that their expertise in international aquatic resources collectively encompasses the scope of the CRSP (including socioeconomic factors that can influence research and adoption of technology generated from research). Candidates for the EEP are nominated by the ME in consultation with the Board, TC, participating institutions and

other sources; nominees must be approved by USAID after concurrence from BIFAD. New members are rotated in as members resign or are replaced. With changes to BIFAD, the appointment of EEP members now appears to rest with USAID.

Owing to several factors, among them attrition and the difficulty of finding qualified diverse candidates who can commit the time needed to serve on the panel and whose participation does not involve a conflict of interest (given that the field of aquaculture is a decidedly small community), the program does not yet have a fully seated four-member panel.

For the greater part of the reporting period, the EEP consisted of one member. This EEP member participated in the 14th Annual Meeting in Seattle and has been involved in all major program activities, including the development of the Philippines, the Ninth Work Plan Request for Proposals, and Regional Plans and others. Over the past reporting period, the ME has proposed four individuals to USAID, of which only one has been appointed to the EEP. This one nominee was approved in May 1997, bringing the EEP to two members.

6. Financial Summary

This section summarizes the expenditures of USAID, non-federal, and host country funds for CRSP research activities and program management. This unaudited information is intended to provide an overview of CRSP program budgets and matching support for the period 1 August 1996 to 31 July 1997. Official financial reports are submitted to USAID via the Management Entity's Research Accounting Office.

The overall funding of the PD/A CRSP was substantially increased under the new grant begun 1 August 1996. Total expenditures (includes USAID funds and matching support from US universities) plus unliquidated obligations (commitments made for experiments in progress through 30 April 1998) were in excess of $4 million for the twelve months ended 31 July 1997. This compares with $7 million of similar expenditures for the entire six years of the prior grant.

Regional spending under the Eighth Work Plan included the addition of South America with the opening of a new site in Peru. Spending was reduced in Asia and increased in Africa as development funds were put into the new Kenya site.

Emphasis, as indicated by funding commitments, was placed upon both global research and research support. Research support efforts had previously been considered part of the Management Entity. With the new grant, a separate Research Support Component was established. Individual projects within this component (Education Development, PD/A CRSP Central Database Management, and Information Management and Networking) are directed by Principal Investigators who have clearly defined work plans and budgets.

Cost sharing contributions from the US institutions and contributions from host countries are presented in the table on the following page. Not all sites reported host country contributions, and those that did may not have fully accounted for in-kind contributions, typically including water, electricity, fish stock, labor, and supplies. The overall percentage of funding borne by US universities is 20 percent, which fulfills the USAID requirement for matching after accounting for grant expenditures under established Memoranda of Understanding with host countries.

7. Staff Summary

The Pond Dynamics/Aquaculture CRSP represents the joint efforts of more than 70 professional and support personnel from US universities. It also represents the collaborative efforts of over 75 scientists, technicians, and graduate students from project sites in five host countries. The expertise of host country and US personnel is broad-based and encompasses the major fields of specialization included in this CRSP: Limnology and Water Quality; Fisheries and Aquaculture; Soil Science; Engineering; Sociology; Data Management, Analysis, and Modeling; Sociology; Biotechnology; Agricultural Economics; Adult Education; and Research Administration.

The program's United States-based personnel is drawn from each of the participating institutions—Auburn University (AU), Oregon State University (OSU), Southern Illinois University, Carbondale (SIUC), The University of Michigan (UM), the University of Arkansas at Pine Bluff (UAPB), the University of Arizona (UA), the University of California at Davis (UCD), the University of Texas (UT), and the University of Oklahoma (UO). Host country staff participate in the CRSP though their involvement with:

Ministry of Agriculture and Livestock, Tegucigalpa, Honduras;
La Lujosa Water Quality Laboratory, Choluteca, Honduras;
El Carao National Fish Culture Research Center, Comayagua, Honduras;
Institute for the Investigation of the Peruvian Amazon, Iquitos, Peru;
National University of the Peruvian Amazon, Iquitos, Peru;
Fisheries Department, Ministry of Tourism and Wildlife, Nairobi, Kenya;
Sagana Fish Farm, Sagana, Kenya;
Asian Institute of Technology, Pathum Thani, Thailand; and
Central Luzon State University, Iloilo City, Philippines.

Cooperating institutions include:

Royal Thai Department of Fisheries, Bangkok, Thailand;
Grupo Granjas Marinas, S.A., Choluteca, Honduras;
Food and Agriculture Organization, Rome, Italy; and
University of Tabasco, Villahermosa, Mexico.

Pond Dynamics/Aquaculture CRSP Advisory Bodies

Board of Directors		Institution
Philip Helfrich	Chair (to 5/97)	University of Hawaii, Kaneohe, Hawaii
Bryan Duncan	Chair (from 5/97)	Auburn University, Auburn, Alabama
Russell Moll	(from 2/97)	The University of Michigan, Ann Arbor, Michigan
L.J. Koong	(from 4/97)	Oregon State University, Corvallis, Oregon
Shadrach Okiror	(from 7/97)	University of Arkansas at Pine Bluff

External Evaluation Panel

Gary Jensen	US Department of Agriculture, Washington, DC
Kevan Main (from 5/97)	Harbor Branch Oceanographic Institute, Sarasota, Florida

Technical Committee		Institution
Raul Piedrahita	Co-chair	UCD
Bill Shelton	Co-chair (from 2/97)	UO

Material and Methods Subcommittee		*Research Area of Expertise*
Carole Engle	UAPB	Social and economic aspects
Karen Veverica	AU	Production optimization
Jim Szyper	UH	Environmental effects

Technical Progress Subcommittee		
Joe Molnar	AU	Social and economic aspects
Shree Nath	OSU	Production optimization
Peter Edwards	AIT	Environmental effects

Work Plan and Budget Subcommittee		
John Bolte	OSU	Environmental effects
Tony Circa	CLSU	Social and economic aspects
Bart Green	AU	Production optimization

At-Large Technical Committee Member

Randy Brummett (from 2/97)	ICLARM, Zomba, Malawi

Technical Committee Liaison

Tracy Gray	American Tilapia Association Monticello, Florida

Program Management Office

Oregon State University, Corvallis, Oregon*

Hillary Egna	Director
Brigitte Goetze	Deputy Director
Danielle Clair	Program Assistant
Sayea Jenabzadeh	Graduate Research Assistant
John Baker	Office Support (from 2/97)
Clare LaFond	Financial Manager (from 6/97)

*Most PMO staff are employed at less than full-time.

Research Support

Oregon State University, Corvallis, Oregon

Education Development Component

Office of International Research and Development

Marion McNamara	Education Development Coordinator
Anita Princehouse	Adminstrative Assistant

Database Management

Department of Bioresource Engineering

John Bolte	Principal Investigator
Doug Ernst	Database Manager
Duncan Lowes	Graduate Research Assistant

Information Management and Networking*

Office of International Research and Development

Brigitte Goetze	Information Manager
Danielle Clair	Assistant Information Manager
Ingvar Elle	Systems Administrator
Deborah Burke	Graduate Research Assistant
Penny Schumacher	Office Support (to 5/97)

*All IMNC staff are employed at less than full-time.

Research Projects

Honduras Project

Auburn University, Auburn, Alabama

Bartholomew Green	US Co-PI, Project Leader (stationed in Tegucigalpa, Honduras)
David Teichert-Coddington	US Co-PI
Claude Boyd	US Co-PI
Marianne Jensen	Administrative Assistant

University of Texas, Austin, Texas

George Ward	US PI

Ministry of Agriculture and Livestock, Tegucigalpa, Honduras

Marco Polo Micheletti	Host Country PI

La Lujosa Water Quality Laboratory, Choluteca, Honduras

Jaime Lopez	Lab Technician
Delia Martinez	Chemist
Eneida Ramírez	Assistant Chemist

El Carao National Fish Culture Research Center, Comayagua, Honduras

Nelson Claros	Chemist
Rene Palcios	Lab Technician

Cooperators:

Grupo Granjas Marinas, S.A., Choluteca, Honduras

John Wigglesworth
Brian Boudreau
John Harvin
Hector Corrales
Rafael Zelaya

Peru Project

Southern Illinois University at Carbondale, Carbondale, Illinois

Christopher Kohler	US Co-PI, Project Leader
Susan Kohler	US Co-PI
Marcos de Jesus	Graduate Student
Karen Vincent	Data Analysis Support

Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru

Fernando Alcantara	Host Country Co-PI
Palmira Padilla Perez	Aquaculturist
German Del Aguila	Technician
Armando Conde Sanchez	Technician
Lamberto Arevalo	Technician
Cesar A. Flores	Technician
Arturo Flores Huang	Technician

Universidad Nacional de la Amazonia Peruana, Iquitos, Peru

Enrique Rios Isern	Host Country Co-PI

Research ponds at Quistacocha Research Station, Instituto de Investigaciones de la Amazonia Peruana, Iquitos, Peru.

Kenya Project

Oregon State University, Corvallis, Oregon

Jim Bowman	US Co-PI, Project Leader
Christopher Langdon	US Co-PI
Tracy Posavatz	Student Assistant

Auburn University, Auburn, Alabama

Tom Popma	US Co-PI
Karen Veverica	US Co-PI (stationed in Sagana, Kenya)
Marianne Jensen	Administrative Assistant

University of Arkansas at Pine Bluff, Arkansas

Rebecca Lochmann	US Co-PI
Peter Perschbacher	US Co-PI

Fisheries Department, Ministry of Tourism and Wildlife, Nairobi, Kenya

Fred Pertet	Director of Fisheries, Kenya

Sagana Fish Farm, Sagana, Kenya

Mathias Wafula	Director
George Onyango	Deputy Director
Felix K. Lagat	Production Officer
Judith Amadiva	Social Development Officer
Danial M. Njoroge	Executive Officer
D.S. Otieno	Assistant Research Officer
James Karuri	Lab Technician
William Kibe	Fisheries Assistant
J.M. Makau	Fisheries Assistant
Steven Irenge	Hatchery Technician
Daniel Mwangi	Hatchery Technician
John Maina	Computer Technician
William Kabethi	Stores Keeper
Wilson Maina Gachuri	Stores Keeper

Thailand Project

University of Michican, Ann Arbor, Michigan

James Diana	US Co-PI, Project Leader
C. Kwei Lin	US Co-PI (stationed in Pathum Thani, Thailand)
Yang Yi	Research Associate
Barbara Diana	Research Assistant

Asian Institute of Technology, Pathum Thani, Thailand

Peter Edwards	Host Country PI
Madhav Shrestar	Post Doctoral Researcher
C. Boonthamchinda	Research Administrator
Dhirendra Thakur	Research Associate
Manoj Yomjinda	Research Assistant
Cao Thang Binh	Graduate Research Assistant

Cooperators:

Asian Institute of Technology, Pathum Thani, Thailand
Harvey Demaine

Royal Thai Department of Fisheries, Bangkok, Thailand
Watana Leelapatera

Royal Thai Department of Fisheries, Ayutthaya, Thailand
Somchai Vaipoka

Philippines Project

University of Arizona, Tucson, Arizona

Kevin Fitzsimmons	US PI
Gary Dickenson	Technician
Brent Skeen	Graduate Research Assistant
Alicia Velasquez	Administrative Support
Kathy Bell	Administrative Support

Central Luzon State University, Iloilo City, Philippines

Antonio Circa	Host Country PI
Eddie B. Jimenez	Technician
Jose Pagaduan	Field Staff
Boy Tomines	Field Staff
Ben Pagaduan	Field Staff
Ruben C. Sevilleja	Director, Freshwater Aquaculture Center

Global Research

Pond Dynamics

Auburn University, Auburn, Alabama

Claude Boyd	US PI
C. Wesley Wood	Research Associate
Julio Queiroz	Postdoctoral Fellow
Prasert Munsiri	In-country Assistant, Thailand
Brenda Wood	Technician

Reproduction Control

Auburn University, Auburn, Alabama

Ronald Phelps	US PI
Kevin Bootes	Graduate Research Assistant
John Arnt	Graduate Research Assistant

University of Oklahoma, Norman, Oklahoma

William Shelton	US PI
Hank Ray	Research Technician
Ana Hiott	Research Technician

Oregon State University, Corvallis, Oregon

Martin Fitzpatrick	US Co-PI, Project Leader
Carl Schreck	US Co-PI
Wilfrido Contreras	Graduate Research Assistant
Rob Chitwood	Hatchery Manager
Ruth H. Milston	Student Researcher
Michael Lucero	Student Researcher
Rick Hornick	Student Researcher

Cooperators:

Oregon State University, Corvallis, Oregon
Grant W. Feist

University of Tabasco, Villahermosa, Mexico
Wilfrido Contreras

Aquaculture Systems Modeling

University of California, Davis, California

Raul Piedrahita	US PI
Daniel Jamu	Research Assistant
Zhimin Lu	Research Assistant

Marketing and Economic Analysis

University of Arkansas at Pine Bluff, Pine Bluff, Arkansas

Carole Engle	US Co-PI, Project Leader
Pierre-Justin Kouka	US Co-PI

Adoption/Diffusion

Auburn University, Auburn, Alabama

Joseph Molnar	US Co-PI, Project Leader
C. Kwei Lin	US Co-PI
Christine Dawson	Graduate Research Assistant
Bryan Walton	Graduate Research Assistant

Decision Support Systems

Oregon State University, Corvallis, Oregon

John Bolte	US PI
Shree Nath	Doctoral Candidate (to 11/96) Research Associate
Duncan Lowes	Graduate Research Assistant
Prisila Darakjian	Graduate Research Assistant

Cooperators:

Auburn University, Auburn, Alabama
Joseph Molnar

Food and Agriculture Organization, Rome, Italy
James Kapetsky

Appendix A. Acronyms

AAAS	American Association for the Advancement of Science
AFGRAD	African Graduate
AIT	Asian Institute of Technology
ALCOM	Aquaculture for Local Community Development Programme
ANDAH	Asociacion Nacional de Acuicultores de Honduras
ASEAN	Association of Southeast Asian Nations
AU	Auburn University
BIFAD	Board for International Food and Agricultural Development
BMP	best management practice
BOD	Board of Directors
BOD_2	biological oxygen demand
CGIAR	Consultative Group on International Agricultural Research
CIESIN	Consortium of International Earth Science Information Networks
CIFAD	Consortium for International Fisheries and Aquaculture Development
CLAR	Center Laboratory for Aquaculture Research
CTU	Celsius Temperature Units
CUL	Catholic University of Leuven
DANCED	Danish Cooperation for Environment and Development
DAST	Data Analysis and Synthesis Team
DSS	Decision Support System
DIGEPESCA	Direccion General de Pesca y Acuacultura
DO	dissolved oxygen
EAP	Escuela Agricola Panamericana
EDC	Educational Development Component
EEP	External Evaluation Panel
EIFAC	European Inland Fisheries Advisory Commission
FAC	Freshwater Aquaculture Center
FAC/CLSU	Freshwater Aquaculture Center, Central Luzon State University
FAO	Food and Agriculture Organization
FCR	feed conversion ratio
FPX	Federación de Agroexportadores de Honduras
GIS	Geographical Information System
GOH	Government of Honduras
HBCU	Historically Black Colleges and Universities
HC	host country
ICA	International Center for Aquaculture
ICLARM	International Center for Living Aquatic Resource Management
IDB	International Development Bank
IDRC	International Development Research Center
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer
IMNC	Information Management and Networking Component
INTSORMIL CRSP	International Sorghum and Millet CRSP
IPB	Institut Pertanian Bogor
ISTA IV	Fourth International Symposium on Tilapia in Aquaculture
JICA	Japan International Cooperation Agency
KMFRI	Kenya Marine Fisheries Research Institute
MDHT	17α-methyldihydrotestosterone
ME	Management Entity

MOU	Memorandum of Understanding
MSU	Michigan State Unversity
MT	17α-methyltestosterone
N	nitrogen
NACA	Network of Aquaculture Centers in Asia Pacific
NARP	National Agricultural Research Project
NCRAC	North Central Regional Aquaculture Center
NIFI	National Inland Fisheries Institute
NMFS	National Marine Fisheries Service
NRM	Natural Resources Management
ODFW	Oregon Department of Fish and Wildlife
OSU	Oregon State University
P	phosphorus
PD/A CRSP	Pond Dynamics/Aquaculture Collaborative Research Support Program
PI	principal investigator
PL	post-larval
PMO	Program Management Office
PRADEPESCA	Programa Regional de Apoyo al Desarollo de la Pesca en el Istmo Centroamericano
PROARCA	Programa Ambiental Regional para Centroamerica
RA	research associate
RECOSCIX	Regional Cooperation in Scientific Information Exchange—Western Indian Ocean
RFP	Request for Proposal
ROH	Returned Overhead
SADC	Southern African Development Community
SANREM CRSP	Sustainable Agriculture and Natural Resources Management CRSP
SEAFDEC	South East Asian Fisheries Development
SIUC	Southern Illinois University, Carbondale
SPAAR	Special Program for African Agricultural Research
UA	University of Arizona
UAPB	University of Arkansas at Pine Bluff
UCD	University of California, Davis
UH	University of Hawaii
UM	The University of Michigan
UNAH	La Universidad Nacional Autonomica de Honduras
UNR	Université Nationale du Rwanda
UO	University of Oklahoma
UPV	University of the Philippines, Visayas
US	United States
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
UT	University of Texas
UV	ultraviolet
WAS	World Aquaculture Society
WRAC	Western Regional Aquaculture Consortium
WWW	World Wide Web

Appendix B. Publications

Regional Research

Central America

Honduras

Asian Institute of Technology

Publication

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Appendix C. Program History

The PD/A CRSP was initiated formally on 1 September 1982 as a Title XII program under the International Development and Food Assistance Act of 1975. The Consortium for International Fisheries and Aquaculture Development (CIFAD), Auburn University, and the University of California at Davis were chosen to participate in a tripartite management of the PD/A CRSP, and CIFAD was designated as the lead group in the management of the program, with Oregon State University serving as lead institution. CIFAD, no longer a functional entity, consisted of the University of Arkansas at Pine Bluff, the University of Hawaii, the University of Michigan, Michigan State University, and Oregon State University. Most of the CIFAD institutions continue to participate in the PD/A CRSP. However, beginning with this Grant and the dissolution of CIFAD, a new advisory structure (see chapter VII) allows greater equity among participating institutions and provides an effective mechanism for new institutions to be represented on the Board of Directors.

Historical Overview of Program Objectives

In 1980, the First PD/A CRSP Preliminary Design Proposal was approved by the Joint Committee on Agricultural Research and Development. The approach for designing the PD/A CRSP included a review and synthesis of the state-of-the-art of pond aquaculture, overseas site visits to determine research needs in cooperating countries, and negotiation of provisional administrative agreements with collaborating institutions. Findings from the literature and field surveys were translated into planning guidelines. The most important needs identified for improving the efficiency of pond culture systems were 1) the need for technological advances to improve the reliability of pond production and 2) the need for economic optimization based on local conditions. The common link was to improve the understanding of pond dynamics.

The 1980 Preliminary Proposal identified four systems which were considered to have the greatest potential for contributing to the supply of low-cost animal protein. These systems, listed in priority sequence according to the proportion of rural poor they would expect to serve, are:

- Small, low intensity tropical pond systems characterized by limited external inputs of feed or fertilizers;
- Cooler water (15-25°C) tropical ponds at medium to high elevations;
- Brackish water and hypersaline ponds, including those in tropical mangrove zones; and
- Higher intensity tropical pond systems, characterized by high external inputs of feed and fertilizers.

The main research objectives for the first five years of the PD/A CRSP (1982-1987 PD/A CRSP Grant) were:

- to compile a quantitative baseline of chemical, physical, and biological parameters for each work location, and to correlate responses of these parameters to various levels of organic and inorganic fertilizer applications to pond culture systems (referred to as the "Global Experiment");

- to compile a baseline of information on hydrology, locally available nutrient inputs, geography, and water quality in each participating country, utilizing available host country resources;
- to observe and document technical constraints limiting fry availability in each participating host country, and to test alternative fry production methods where appropriate;
- to develop models describing the principles of pond culture systems.

These objectives were modified in 1986 because of technical, geopolitical, and financial considerations. A data analysis and synthesis component (now referred to as Data Analysis and Synthesis Team or DAST) was added in 1987 with the following objectives:

- to statistically analyze data from the field experiments to describe global and site-specific variations in pond culture systems;
- to synthesize data from the Global Experiment and develop descriptive models of the physical, chemical, and biological processes that regulate the productivity of pond culture systems;
- to develop conceptual frameworks for one or more pond management models and develop operating instructions consistent with each conceptual framework;
- to compile a manual of operating instructions describing pond management procedures for optimizing yields, increasing the reliability and improving the efficiency of pond culture systems.

The 1987-1990 Continuation Plan addressed the most important objectives of the original plan, with the goal of synthesizing the results of the first three work plans as a staged progression into a conceptual model of pond aquaculture systems. This model was used to identify research needs which were prioritized and translated into objectives for field research projects specific for each host country.

The programmatic and operational objectives in the 1990-1995 Continuation Plan were:

- to continue to develop technology, through research, to overcome major problems and constraints affecting the efficiency of pond aquaculture in developing countries;
- to maintain or improve environmental quality through proper management of aquacultural systems;
- to stimulate and facilitate the processing and flow of new technologies and related information to researchers, to extension workers, and ultimately, to fish farmers in developing countries;
- to promote activities that encourage faculty and researchers to build and maintain linkages;
- to create opportunities for greater multidisciplinary research in aquaculture and to enhance the socioeconomic and ecological aspects of the PD/A CRSP;
- to encourage informational and data exchange among international agricultural research centers, universities, the non-government research community, and USAID centrally funded and mission-funded projects;
- to expand results derived from the site-specific research to regional recommendations through a global analysis of the data; and

- to use an ecosystem approach to arrange the research agenda and integrate technologies.

While many program objectives have been met over the past decade of PD/A CRSP research, the original program goal, that advances in pond aquaculture are based on greater understanding of pond dynamics, continues to be relevant. It serves as an effective organizing principle for new research that aims at resolving constraints facing farmers and commercial aquaculturists in the US and host countries.

Historical Overview of the PD/A CRSP – Agreements with Host Countries, 1982–1995

With the initiation of the CRSP Grant in 1987, Host Country and US institutions renewed their Memoranda of Understanding. These Memoranda reflected the structural changes (i.e., the consolidation of the CRSP from seven countries to three) that had occurred since 1982. While several US universities collaborated at each country site, only one represented the US in each Memorandum. This structure provided for a more equitable arrangement with the Host Country institutions.

For example, The University of Michigan, a CIFAD member, had separate Memoranda with the Thai Department of Fisheries and the Asian Institute of Technology. The University of Michigan and the Thai Department of Fisheries acted as the lead US university and Host Country institution, respectively, in Thailand. This provided a focal point for the other institutions that worked on the CRSP project in Thailand. The University of Michigan in turn had informal subagreements with Michigan State University and the University of Hawaii.

Likewise, the National University of Rwanda (UNR) held a Memorandum of Understanding with Oregon State University, the lead US university on the Rwanda project. As lead, Oregon State University was the main contact for the Rwandan researchers and was responsible for overall coordination of US CRSP research activities in Rwanda. Auburn University and the University of Arkansas at Pine Bluff collaborated with Oregon State University in Rwanda.

In Honduras, Auburn University held a Memorandum with the Ministry of Natural Resources (since renamed the Ministry of Agriculture and Livestock). In Egypt – a bilaterally funded project under USAID/Cairo – OSU held the Memorandum of Understanding with the Egyptian National Agricultural Research Project (NARP).

This hierarchical structure differed from the contractual arrangements among US universities and the Management Entity (ME). While all participating institutions had access to the services of the ME, past contractual agreements were made directly with Auburn University, the University of California at Davis, and CIFAD. CIFAD in turn had formal contracts with its member universities: The University of Michigan, Michigan State

University, Oregon State University, the University of Hawaii, and the University of Arkansas at Pine Bluff. When CIFAD was dissolved, all institutions were elevated to the same contractual status. The hierarchical arrangement arrived at through the designation of lead US universities was seen to promote a greater degree of cooperation among US universities and greater involvement of the host institutions at the highest level. Certain programmatic and fiscal responsibilities were delegated to participating US institutions through subagreements from the ME. For the Egypt Project, the ME had formal contracts with each participating university.

CRSP Memoranda of Understanding, 1996 to present

At the present time, Memoranda of Understanding are in place between the following participating CRSP institutions:

- International Center for Aquaculture and Aquatic Environments, Auburn University, and the Ministry of Natural Resources, Republic of Honduras;
- Southern Illinois University, Carbondale, and the Institute for the Investigation of the Peruvian Amazon and the National University of the Peruvian Amazon;
- Oregon State University Fisheries and Wildlife Department and the Department of Fisheries, Ministry of Wildlife and Tourism, Kenya; and
- The University of Michigan and the Asian Institute of Technology, Thailand.

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Appendix A. Acronyms

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